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REPLY

TO THE

CRITICISMS OF JAMES D. DANA

BY

JULES MARCOU.

INCLUDING

DANA'S TWO ARTICLES

WITH A LETTER OF LOUIS AGASSIZ.

ZURICH

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REPLY

TO THE CRITICISMS OF JAMES D. DANÁ.

Different views of a question are desirable and beneficial in order to elucidate scientific observations and theories, but it is not the same with controversial writings, which are usually a disgrace to science and scientific men. Fully convinced that geology has never been advanced a single step by such means, I have been very reluctant to engage myself on this irritating ground, although many opportunities have been presented to me. But though such discussions are generally useless and even injurious, there are cases in which silence may do harm; for if the attack rest without reply, many persons may believe the charges advanced to be true, and so the progress of science will be checked, and unjust blame and discredit be thrown where they are not due. It is to avoid being placed in this position, that I now reply in a few words to the two articles of James D. Dana in *Silliman's Journal*, which contain so severe an attack on my observations.

The criticisms of my opinions on American geology in *Silliman's Journal* commenced in 1854, and have since continued with every opportunity; as yet I have not replied to them, unless it can be called a reply to have reprinted them in full in my *Geology of North America*, without a word of comment.

I was silent, first, because at the time the first article against me appeared,[1] I was in the deserts of California; secondly, because the attack was anonymous, and I dislike fight-

1) *Silliman's Journal*, vol. xvii, March 1854; *Notice of a Geological Map of the United States*, etc.

ing in the dark; and thirdly, from entire want of faith that any good could result from such personal controversy.

The review of a portion of the Geological Map of the United States and British Provinces, published in *Silliman's Journal*, Nov. 1856, by W. P. Blake, contains statements that I cannot possibly consider as seriously presented. Besides, Mr. Blake received, without my knowledge, my specimens to describe, and my notes to publish; and from motives of delicacy should bave been the last person to attack my observations in the Far West, instead of which he began directly, giving my specimens into unfriendly hands for description, and publishing, contrary to my desire, all the scratches and pencil marks to be found among my notes. The following is an example of his consideration for my observations. In his travels for the Pacific Railroad Exploration, Mr. Blake crossed my route only at *one locality*, the Cajon Pass near San Bernardino, California. In his report upon my collection, Mr. Blake says: «Mr. Marcou states that he saw rocks in the Pass «precisely similar to those found between Rough and Ready, «Grass valley and Nevada city, which contain veins of auri-«ferous quartz. To me the rocks of the lower portion of the «Pass appeared to be chiefly metamorphic, while those bear-«ing the quartz veins at Grass valley and vicinity were evi-«dently in great part of erupted greenstone. The specimens «which Mr. Marcou notes as coming from the Cajon Pass were «*most probably brought through there* from Armagosa mines in «the Great Basin.» (See: *Pacific Railroad Explorations*, vol. III, *Report on the Geology of the route of Lieut. Whipple*, pag. 97, 4° edition.) In reply to this, I say that I saw the rocks in the Cajon Pass forming immense dykes, and my specimens were táken from the rocks *in situ*. Mr. Blake describes the Cajon Pass in his report of his exploration, and I looked eagerly to find the facts on which he grounded his flat contradiction of my observations; but I only found the following: «This part of the valley was *past in the night* and it was there-«fore impossible to make detailed observations on the varie-

« ties and peculiarities of the granitic rocks. » (See: *Pacific Railroad Explorations*, vol. V, *Geological Report of routes in California*; Cajon Pass; p. 88. 4° edition.)

The last two articles, contained in the numbers for November 1858 and January 1859, are signed by James D. Dana, one of the two proprietors of the *Silliman's Journal* and the chief editor of the Geological part, and must be considered as confirming all the previous ones. To these I wish now to reply, although the only serious objections in Dana's criticism are made by another person, who is not named. The following is the first of Dana's reviews.

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(Extract from the *Silliman's Journal of Science*, second series, vol. XXVI, n° 78, November 1858, p. 323 etc.)

Review of Marcou's „Geology of North America",[1]) by James D. Dana.

The volume on American Geology just published by Mr. Jules Marcou, demands more than a passing notice. Coming from a Professor in the Federal Polytechnic School of Switzerland, who is known to have traversed this country widely, and whose memoirs and American geological map form part of the publications of the Geological Society of France besides being distributed through several European journals, it is of interest to all to inquire into the character of the work and the reliability of the author's conclusions.

It will be remembered that former writings of the author on the same topic have been noticed in this Journal; and as he takes exceptions to the statements which have been made, it is the more incumbent on us to reconsider the subject with his later volume before us. We wish only to seek out the truth, that we may honor it, and here register it for the use of the science.

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1) Geology of North America, with Two Reports on the Prairies of Arkansas and Texas, the Rocky Mountains of New Mexico, and the Sierra Nevada of California, originally made for the United States Government; by JULES MARCOU, Professor of Geology in the Federal Polytechnic School of Switzerland, formerly United States Geologist, etc. 144 pp., with three maps and seven plates. Zurich, 1855.

With regard to the title of „United States Geologist," we remark for the enlightenment of foreign readers, that there is no such office under the Government, and no national Geological Corps. When an expedition for exploration and survey is organizing, some person is usually associated with the party for scientific research, by appointment from the Department in charge of the survey. Those selected are sometimes good geologists and sometimes otherwise.

The work on the Geology of North America contains, (1) an account of the author's researches in America; (2) a general review of the geology of the continent with reference to the geological map; (3) a classification of the mountains of part of North America; (4) a review of his reviewers; (5) a history of the progress of American geology. The question important to geologists — to European more than American — is, whether American geology is correctly represented.

I. History of Geology. — Mr. Marcou commences by republishing the observations of Maclure on the Geology of the United States with the accompanying map, from vol. VI. of the Transactions of the American Philosophical Society, doing full justice to this earliest of American explorers. He reviews the labors of many who have followed him, making honorable mention, as he should, of Vanuxem, one of the ablest of our geologists, of Hitchcock, Owen, and others. But we are sorry to see imperfections in the history, which evince that personal disappointments have warped the author's judgment. Professor Hall's connection with American palæontology is well known to the world. Mr. Marcou, enumerating in a paragraph the cultivators of palæontology in America, mentions «Lesueur, Harlan, Jefferson, Say, Green, Bigsby, Rafinesque, Troost, Morton, Redfield, Lea, and Hitchcock;» then, Conrad and Leidy, as taking the lead of all, the «best palæontologists in the United States,» and ends with what he calls «the young palæontologists of the present day,» «Dr. Shumard, Holmes, Newberry, Meek, Wyman, Billings, etc.»; Hall's name is not included. He has honored him, however, with a separate paragraph, in which he speaks of the «Palæontology of the State of New York by James Hall,» as «a very useful work;» and then closes a disparaging sentence with, «the best part of it being the plates drawn by Mrs. Hall, and also the geological order.» Conrad and Leidy are highly appreciated. But in his treatment of others, the author shows that he has himself been reviewed. This is apparent also in the closing sentence of this brief History of American Geology. «Maclure, Vanuxem, Hitchcock, Taylor, Conrad, Emmons, Lyell, de Verneuil, and David Dale Owen, are the *only discoverers*; other geologists have extended and detailed the just views and grand ideas that these illustrious savants were the first to divulge:» — an association of names that will surprise, by its omissions if not otherwise, those who know much of science in America and little of the influences that have operated upon the author of this history. Mr. Marcou shows again that he has had reviewers, in the remark that he makes about «the half dozen hieroglyphical pamphlets» published as the

Geological Report of Progress of the Canada Survey.[1]) He evinces that his American conclusions have met with opposition, also, by his slight of Foster and Whitney's investigations in northern Michigan, and of the various researches of the Professors Rogers, and by his studied neglect of others.[2])

There are also imperfections in the History arising from a partial acquaintance with the subject and the science. Thus he speaks of Mr. E. James as having been the first to recognize the «New Red Sandstone» on the slopes on the Rocky Mountains, when all he had any knowledge of was *a red sandstone.* He speaks of the knowledge of the geographical extension of the «New Red» being due to Dr. D. Houghton and others for Lake Superior, when no evidence of its existence in the Lake Superior region is yet known or was ever detected. He speaks of the discovery of the «Old Red» by Taylor, when the so-called «Old Red» is only the upper part of the American Devonian.

Without further specifications, it is plain that in this history the author has neither dealt fairly with others or the subject.

II. Review of the Reviewers. — We refer to this chapter merely to add, that the personal feeling above attributed to the author, is here acknowledged. We are very sure, that only the belief that Mr. Marcou was propagating in his publications erroneous views abroad, led to the notices of his memoirs and former map that have so chafed him. On no other ground than a desire to promote the interests of science have the pages of this Journal been open to the criticisms.

III. Mountain Systems. — The author describes the mountain systems of North America and their ages, as he supposes they must

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1) „As to the survey of the two Canadas, it was honored at the two Great Universal Exhibitions of London 1851, and Paris 1855, with medals, decorations of the „legion of Honor, and even with a Knight's title from the Sovereigns of England „and France, and its Director General W. E. Logan, aided by T. Sterry-Hunt, mineralogist of the survey, has shown to the scientific world, with so much modesty „and talent, the *grand results and discoveries* of their joint survey, that nothing remains for others to say, but to express their admiration and gratitude for the half „dozen hieroglyphical pamphlets they have published, under the title of *Report of „Progress of the Geological Survey of Canada.*"

2) Mr. Marcou says, with characteristic self-complacency, and with evident irritation because others do not call „New Red," what he does: „The brothers Rogers and James Hall try their best to suppress the New Red Sandstone formation in America," &c.; and after making various absurd statements and suggestions, bringing in Logan for a share of his attempted ridicule, he adds respecting them, „I would advise these honorable savants to consider if one of these determinations would not be preferable.."

be according to the theoretical views of Elie de Beaumont. A determination of the age and relations of each by means of observed facts would be positive knowledge and of some service to the science.

IV. Researches. — The points in the explorations of the author which give his work special prominence, are the assumed identification —

(1.) of Triassic rocks in the Lake Superior region;

(2.) of the Permian Formation over the slopes of the Rocky Mountains;

(3.) of Triassic rocks in the same Rocky Mountain regions;

(4.) of Jurassic rocks in the same region.

We should take pleasure in claiming for the author the establishment of either one or all these points, if we could justly do it. The progress of American geology is largely due to foreign geologists — to Lyell of England, and De Verneuil of France; and they are honored for their labors. They were wise men; appreciating geological evidence, they used it cautiously and surely, and made each step a step of real progress. They did not conclude, when they came across *a* red sandstone, that it was *the* «New Red» or *the* «Old Red;» or on the discovery of a *magnesian* limestone, that it was *the* magnesian limestone of the Permian. They knew, with all other geologists, that mere color and mineral characters were the very worst test of equivalency between the rocks of the two continents; that the test will not answer even for the United States alone; that an appeal to such characters in this period of geological science betrays great want of experience. They came to the country expressly to subject all such considerations to the higher test of organic remains, and in this their great merit consists. Mr. Marcou, we regret to see, has taken the course which they rejected and which science long since repudiated. It is true the region he examined was nearly destitute of fossils. But there was so much the more reason for doubting, as all others had done before him.

1. *Triassic Rocks in the Lake Superior Region.*

The only evidence that these rocks are Triassic, given by the author, is of the superficial kind just referred to. He has not claimed to find a fossil in the beds or any proof that decides the question. He remarks that Dr. Jackson «confirmed the justice» of the view by finding beds with *Pentamerus oblongus*, an Upper Silurian fossil, on Keweenaw Bay. But it is known that the strata of Keweenaw Point overlie the red sandstone; and Hall has shown them to be Lower Silurian from the fossils collected there by Foster and Whitney.

(See F. and W.'s Report, Part I, p. 118.) Even if the red sandstone were above the Silurian, this would not make it Triassic, according to any known rule of geological reasoning.

The similarity of the beds and the associated trap to the Connecticut River rocks, led early to the *supposition* that both migt be of the same age, but it was no basis for such knowledge as Mr. Marcou claims. Foster, Whitney, Hall, Logan, and others, have been over the same ground, and argue from the fossils and superposition that the rocks are as old as the Potsdam Sandstone. And yet Mr. Marcou still maintains, against all the investigations more recent than his own, and on evidence which geologists know to be worthless, that the rocks are *Triassic*. Mr. Marcou states that these geologists hold the *old* opinion, when on the contrary his' view is the old one, and the only one current until the evidence became known which these geologists themselves brought forward.

2. *Permian Rocks in the Rocky Mountains.*

In the «Itinéraire Géologique du Fort Smith et Napoléon, (Arkansas) au Rio Colorado de Californie,» in 1853,[1]) Mr. Marcou states, in his notes for Dec. 22, after describing what he calls the *New Red Sandstone* of the region, «Puis on a au-dessous un calcaire magnésien ou dolomitique épais à stratification régulière de $1/2$ à un pied d'épaisseur, plongeant au nord sous un angle de 10 à 15°, en stratification concordante avec le *New Red*, et quelques assises du *magnesian limestone* alternant avec le grès rouge à la base. Dans ce *magnesian* on a une couche avec fossiles très-mal conservés; je crois reconnaître des fragments de *Belemnite?* un *Nautilus?* un *Pteroceras?* Quatre milles après avoir marché sur ce *magnesian* on a la lave du volcan qui la recouvre; et nous campons sur la lave, non loin des cones secondaires du grand volcan. Pas de diluvium.» And the «Résumé» by himself, published in the same volume, says respecting these observations: «Shortly after quitting the Colorado Chiquito we found here, with the last beds of the red clay of the Trias and in concordant stratification, a magnesian or dolomitic limestone, with very regular strata from half a foot to one foot in thickness. Several beds contain fossils badly preserved; among which I recognised, however, a *Nautilus*, a *Pteroceras*, and a *Belemnites*. This formation, which is placed between the Carboniferous and the Trias, corresponds, without doubt, to the magnesian limestone of England, and is a new member which I add to the series of secondary rocks in North America. «This magnesian limestone has only four miles of

1) Published in the Pacific Railroad Reports, vol. III.

extent in the place where we crossed it, and disappears beneath lava and volcanic ashes. I have observed it farther to the west, and it appears also to occupy eastward one of the lesser chains of the Sierra de Mogoyon.»

In the new work, this paragraph remains the same, except that in the place of «a Pteroceras, a Belemnites,» it reads «a Gasteropoda, and perhaps a Belemnites;» and after the words magnesian limestone, in the line before the last, «(Permian)» is inserted.

When the discovery of Permian fossils west of the Mississippi was announced, a few months since, before the Geological Society of France, Mr. d'Archiac put forward Marcou's claim to the first discovery of the Permian in the Rocky Mountains, basing it upon this very observation, stating that this *magnesian limestone* was compared by him with the magnesian limestone of England, but that the fossils were too imperfect for determination.[1])

Here then, although the Permian magnesian limestone of one part of England is not represented by a similar limestone in all other Permian regions of Britain, nor in a great part of the Permian region on the Rhine and in Russia; although Murchison says, «In the exploration of Russia, geologists were taught by the diversified Permian group not to dwell on the local mineral distinctions of central or western Europe, but to look to the wide spread of certain fossil remains, which, in vastly distant countries, occupy the same horizon;» although in North America, magnesian limestones are known of all ages, of the Potsdam, Trenton, Upper Silurian, Devonian, and Carboniferous eras; and although it is very common in all formations that limestones are equivalents, even on the same continent, of sandstones and shales; yet we have the decision that *a magnesian* limestone in the Rocky Mountains, lying beneath what is regarded as the «New Red Sandstone,» is the equivalent of *the* magnesian limestone of England. This certainly cannot be regarded as a safe deduction from geological evidence. The fossils were too imperfect to be identified. Yet among them, «a *Nautilus*, a *Pteroceras*, and a *Belemnite*» were recognized; or as stated in his new work «a *Nautilus*, a *Gasteropoda* [he meant to say *Gasteropod*, the singular number], aud perhaps a Belemnite.» Now «a Nautilus» proves nothing as to its being *the* magnesian limestone; «a Pteroceras» is direct testimony against it; and «a Belemnite»? according to all authors, affords the idea no more encouragement. «A Nautilus, a Gasteropod, and a Belemnite?» prove this magnesian limestone to be Cretaceous, or Jurassic, and not older than Jurassic, if the evidence may be used at

1) See this Journal, this volume, p. 260.

all. The cautious geologist would have certainly doubted his «New Red» or Triassic, if he found it overlying beds containing what was probably a Belemnite. The evidence, if worth anything, abolishes both the Triassic and the Permian together.[1])

We conclude, therefore, that credit cannot be claimed by or for the author, with regard to the discovery of the Permian in the Rocky Mountains.

3. *Triassic Formation in the Rocky Mountains.*

Mr. Marcou observes that «this formation, which I was the first to notice and recognize in the West, (see *A Geological Map of the United States and the British Provinces of North America*; Boston, 1853, p. 42.) attains a very considerable development, and according to my observations has a thickness of four or five thousand feet.» Three divisions are made out by him, (1) the lower, the equivalent of the ***Bunter Sandstein***; (2) the middle, of the ***Muschelkalk***; (3) the upper, of the ***Variegated Marls*** or ***Keuper***. Here, then, we have not only the Trias identified, but even its European subdivisions — though with an acknowledgment that the divisions are not «very certain.» We think it was a risky conjecture, for he found no fossils whatever to sustain the division into ***Keuper***, ***Muschelkalk***, and ***Bunter Sandstein***. This off-hand settling of a problem that requires great care even among the fossiliferous beds of Europe, was a bold exploit in geological gymnastics.

But as to the great Triassic formation itself, the only palæontological evidence is from a specimen of fossil wood, met with in latitude 35° 42′ 32″ N., and longitude 99° 36′ 10″ W., «a full grown tree with branches, very much resembling the ***Pinites Fleurotii*** of Dr. Mougeot which is found in the New Red Sandstone of the Val d'Ajol in the Vosges;» after which he adds, «and this establishes a connection between the ***New Red*** of France and that of America.» Thus one single fossil – that one, a species of Pine, and only «very much resembling the ***Pinites Fleurotii*** of Dr. Mougeot», ***establishes***. This is a very strong word for a geologist to use on evidence so small

1) This attempt at the identification of Permian beds in the Rocky Mountains, is in strong contrast with the method of research of Professor Emmons in North Carolina. Prof. Emmons's discovery in that State of Thecodont Saurians, the same group of Reptiles that characterizes the Permian in Europe, constitutes a strong argument in behalf of the existence there of this formation. And if a full survey of all the fossils, both of plants and animals, and a comparison with those of Europe, lead to a modification of the view, it is no discredit to him. He has the honor of aiding in bringing about the comparison and helping on towards the final result. Mr. Marcou's dashing style of work is equally in contrast with the mode of investigation which has at last resulted in detecting Permian strata west of the Mississippi.

and so uncertain, with the fate of four or five thousand feet of rock at stake, and with the beds next beneath containing «perhaps Belemnites.» The prudent observer would have said, «establishes nothing;» and such is the fact. The gypsum, the marls, red color, and other such characteristics are also mentioned to sustain the parallelism. But it is now well known that gypsum, marls, and red color occur both in the Cretaceous and Permian of the west, well illustrating the remark, that such proofs are worse than useless: they have always been a fertile source of error; they might have warranted a bare suggestion but no more, and as far as suggestion goes, that of James had long the precedence.

On *such* evidence, a region over the Rocky Mountains which is one thousand miles from north to south and eight hundred miles from east to west. is for the most part colored on the map as Triassic, or «Terrain du Nouveau Grès Rouge.» Such a region—1000 miles by 800—would take in quite a respectable part of the continent of Europe.

The Triassic will probably be identified over the Rocky Mountain Region. But this going ahead of discovery shows more eagerness than good judgment or science.

4. *Jurassic Rocks in the Rocky Mountains.*

The strata referred by the author to the Jurassic age were observed by him over the Llano Estacado and other regions in the vicinity. The identification in the case of these beds rests upon organic remains, as it ought; yet there is the same faith in mineral coincidences that has before been pointed out. The species mentioned are the *Gryphea dilatata* var. *Tucumcarii*, an Ostrea very near *Ostrea Marshii*, a *Trigonia* and a species of *Astarte*; but the identification rests mainly upon the *Ostrea* and *Gryphea*, which are figured on plate 4. Great importance, therefore, attaches to the right determination of these species; for if not Jurassic, if associated in other strata in the west with well known Cretaceous species, they serve as credentials for the Creteceous instead of the Jurassic.

The bearing of the evidence from these fossils has been discussed in this Journal by Wm. P. Blake,[1] who has pronounced them Cretaceous; and this conclusion was previously arrived at by Professor Hall. But these persons are among the reviewers whom the author discredits, and we have consulted another able palæontologist, highly commended by Mr. Marcou. The following are the views on the subject, which he has furnished us:

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1) This Journal, [2], xxii, 383, 1856.

«The species which Mr. Marcou refers to *Gryphea dilatata* Sowerby, is the true typical form of the Cretaceous species, *Gryphea Pitcheri* of Morton, as is shown by Conrad in the Mexican Boundary Report, vol. i, p. 155, pl. vii, fig. 3 and pl. x, fig. 2; see also Professor Hall, in the Pacific Railioad Reports, vol. iii, plate 2, figs. 1 to 6; and Dr. B. F. Shumard in Marcy's Report on the Exploration of the Red River, plate 6, p. 205. As it is known to range through a considerable thickness of rocks in the Southwest, containing numerous well-known Cretaceous fossils, (on which Dr. G. Shumard in the Transactions of the St. Louis Academy of Sciences, vol. i, p. 289, may also be consulted), we may safely conclude that it is distinct from Sowerby's Jurassic species. A glance at Morton's figure (Synopsis Organic Remains, plate 15, fig. 9), drawn from the original specimen from Arkansas, will satisfy any one of its identity in species with Mr. Marcou's figure (plate 4, fig. 2).

«The Oyster figured on the same plate as the *O. Marshii* Sow. is the shell described by Dr. B. F. Shumard in Captain Marcy's Red River Report (p. 205, and fig. 2, plate 5), under the name of *Ostrea subovata.* It occurs in the Cretaceous at Fort Washita, along with *Ammonites vespertinus* Morton, *Gryphea Pitcheri* Morton, (G. dilatata of Marcou), and species of *Exogyra*, *Pecten*, *Astarte*, etc. Both of these species, the *Ostrea* and *Gryphea*, were found extensively through the Cretaceous formation west of the Mississippi by Dr. G. Shumard.»

According, therefore, to the best recent authorities, the fossils supposed to be Jurassic are really Cretaceous, and no evidence of Jurassic rocks in the great west is published as such by Mr. Marcou. This is bad luck for the Jurassic, Triassic and Permian of the Rocky Mountains, on which his claims to a place among the «discoverers» rests. His results, reduced to the simple facts ascertained, amount only to this—that the geology of the Rocky Mountain region includes Cretaceous and Carboniferous rocks—a fact that was quite well known before.

Whoever than may identify true Permian, true Triassic, or true Jurassic strata, beyond the Mississippi, will not have borrowed from Mr. Marcou, and can owe him no credit.

But the subject is not one of mere credit to any person; for it is unfortunate in its bearing on the progress of geological science to have false views about some 500,000 square miles of territory, and much more besides, spread widely abroad through reputable Journals, and Transactions of distinguished European Societies.

We might here leave the author's researches. A few other topics, however, may have a brief word. And while criticising his labors, we would say that his work contains many observations that are better than his inferences.

We cite, at first, from our excellent palæontologist again respecting some Cretaceous and Carboniferous fossils. «The large *Gryphea* or *Exogyra* (plate 3, fig. 1) referred to *G. sinuata* of Sowerby, I am strongly inclined to believe is *E. ponderosa* of Rœmer, (Kreide von Texas, plate 9, fig. 2), which is only a variety of *E. costata* Say, as has been shown by Conrad in the Mexican Boundary Report, page 154, plate 9, fig. 1. The figure given by Rœmer represents a small individual, but he mentions that it grows to a great size. The only difference between *E. ponderosa* and *E. costata*, is that the latter is generally marked by distinct radiating costæ, while the former has none, or is but very obscurely marked in this way. There is, however, every intermediate gradation in this respect, between the two varieties. Both varieties occur in New Jersey, Alabama, and Tennessee, as well as in the Southwest. Sometimes the var. *ponderosa* attains a very large size, and it is not unfrequently from two to three inches in thickness.»

«The *Gryphea Pitcheri* of Marcou (plate 5) has well marked differences from his *Gryphea dilatata* (the true *G. Pitcheri* of Morton). In referring the shell to *G. Pitcheri*, he follows Rœmer, who also fell into the same error, (Kreide von Texas, p. 75, pl. 9, fig. 1). These differences are seen in the figures. Compare figure 5, plate 4, with that of his *G. dilatata* and Morton's figure of the true *G. Pitcheri*: the beak of the latter is truncated while that of the former is angular and laterally curved. This peculiar form has been noticed by Conrad (Boundary Survey Report, vol. i, plate 9, fig. 2 *a b*) as a variety of *G. Pitcheri* and designated *G. Pitcheri* var. *navia* (see also Hall, Pacific Railroad Reports, vol. iii, p. 100). I feel convinced that it is distinct from the true *G. Pitcheri* of Morton, (Marcou's *G. dilatata*).»

«The shell figured on plate 7, fig. 3, as *Spirifer striatus*, is the *S. cameratus* of Morton, (Amer. Jour. Sci., xxix, 1836, p. 150, pl. 2, fig. 3) as has been determined by Prof. Hall. Rœmer described it under the name of *S. Meusebachanus* (Kreide von Texas, p. 88, pl. xi, fig. 7), and in Stansbury's Report (Expedition to the Great Salt Lake) it is named *Sp. triplicatus* by Hall. Owen referred it to *Sp. fasciger* Eichwald. It is very common in the west, ranging from Ohio to the Rocky Mountains, and from Nebraska to New Mexico; Mr. Hayden found it in the Black Hills. It is known to range up nearly to the base of the Permian in Kansas; but I have no knowledge of its having ever been found in *Lower* Carboniferous rocks. Figure 2 on the same plate also referred to *S. striatus*, I am inclined to believe is not that species; some four or five American species appear to have been confounded by different authors under that name. There are many other American Carboniferous species set down as identical by Mr.

Marcou and others, but it is well known to American palæontologists that the whole subject requires careful revision. »

« Mr. Marcou, on page 67, in a note, mentions that fossils from Vancouver's Island, have been determined as Cretaceous by F. B. Meek; but he thinks the determination an error, and that they are Jurassic. In the paper referred to (Trans. Albany Institute, vol. iv, p. 37), Mr. Meek speaks of the fossils placed in his hands by Dr. Newberry as belonging apparently to two rocks. Part of them he pronounced decidedly as Cretaceous—among them a *Baculite*, which is not distinguishable from *B. ovatus.* As regards the rest, which were the larger part, he gave no decided opinion. Subsequently, (but before the publication of Mr. Marcou's work) he mentioned to Dr. Newberry that the latter were probably Jurassic, and so it is stated by Dr. Newberry in the Pacific Railroad Report, vol. vi, p. 66.»

On page 64, Mr. Marcou speaks of the *Coal Measures* at Umpqua in Southern Oregon, where they are not known. He has overlooked the Eocene Tertiary of California. He makes the strata in California, from which Dr. Trask describes Baculites and Ammonites, Jurassic, when they are obviously Cretaceous. But it is not necessary to enter into further details.

V. Geological Map. — This map is open to most of the objections noticed in the former reviews in this Journal,[1]) and we need not repeat. With regard to the region beyond the Mississippi, we refer again to the palæontologist whose opinions we have cited, as he is well acquainted with that part of the continent. He observes respecting the great yellow (Triassic) area on the map, of more than 500,000 square miles: « We now know beyond any reasonable doubt that all the country from the Platte to the British Possessions, and from the Missouri to the Black Hills is occupied by Cretaceous and Tertiary rocks. And as regards the region from the Platte southward to the Red River, very far the larger part is known to be *not* Triassic, while it is possible that the Trias may occur in some parts of it. »

« The surface formations of the Llano Estacado, instead of being Jurassic, are Cretaceous; this is plain from the section of Pyramid Mountain, and also from numerous other facts collected by recent explorers. If the Jurassic rocks exist there, which I am inclined to believe is the case, they are, as at the Black Hills, an *underlying* and not an overlying rock.» Again, «over the region, north of the Llano Estacado which on the map is colored as Jurasssic, the Cretaceous and Tertiary probably extend; but the Jurassic may be looked for over a narrow outcropping belt along the east side of the crest of the mountains.» These observations are by one who has facts as

1) Volume xvii, p. 199, 1854, and xxii, p. 383.

a basis for his conclusions, and who admits a doubt until it is fully removed by investigation.

In conclusion, we would say that our reconsideration of the labors of Mr. Marcou in America has not raised our estimate of their value. We know well that if any American geologist had mapped out strata and synchronized those of America and Europe on such data as have satisfied the author of the «Geology of North America,» he would have been deemed young in the science, with much yet to learn before he could have a sober hearing. We cannot, therefore, think that his former reviewers and opponents deserve, because they differ from him, either to have their names expunged from American geological history, or thrown into discredit; nor do we believe that their reputations will seriously suffer from the judgment of our ambitious Rocky Mountain explorer. Finally, our readers must be fully persuaded, that «Marcou's Geology of North America,» is not «good authority,»—except with regard to the author and his style of work.

J. D. Dana.

UNITED STATES GEOLOGISTS. — Mr. Dana commences by «enlightening foreign readers with regard to the title of *United States Geologist*,» and says there is no such office under the government. A sufficient answer to this statement is found in Dana's address as President of the *American Association* for the year 1854, on retiring from the duties of President, entitled: *On American Geological History*; New Haven, 1856; at page 5, I find J. W. Foster and J. D. Whitney *United States Geologists*. The quarto report of a *Geological Survey of Wisconsin, Iowa, und Minnesota*, 1852, is signed by David Dale Owen, *United States Geologist*. The octavo *Report of a Geological Reconnaissance of Wisconsin in* 1848, is signed by D. D. Owen, *United States Geologist for Wisconsin*. The *Report on the Geology of the Lake Superior Land District*, 1850—51, in two parts and two volumes, is signed in each by J. W. Foster and J. D. Whitney, *United States Geologists*. The *Report on the Geological Survey of the Mineral Lands of Michigan*, 1850, is signed by Charles T. Jackson, *United States Geologist*.

These examples show that the title of *United States Geologist* is sufficiently common and well understood, and although there is no national geological corps, the United States government employs geologists who then become *United States Geologists*.

HISTORY OF GEOLOGY. — In the Introduction to my *Geology of North America* are these words: «Strange notions «upon the geological discoveries that have been made in «America, and some facts quite distorted and misrepresented, «having found admittance into several works, especially an «address: *On American Geological History*, by James D. Dana, «and in the text of a «*Geological Map of the United States and* «*British North America*», by Henry D. Rogers, where there «is a paragraph entitled: *History and Literature of Geological* «*Research in the United States*; I thought it would be more just «to those who made these discoveries, to cite from their own «works, giving the *official date* of their publications, so that «each one may be able to judge for himself of the truth and «value of their discoveries. To this end I have given a Chapter «entitled: *A Synopsis of the History of the Progress and Discov-* «*eries of Geology in North America*, in which I have placed «quotations taken from all the official sources to which I have «had access.»

Mr. Dana has devoted a page of his *Review* to this *Synopsis*, and concludes by the following sentence: «Without further specifications it is plain that in this History the author has neither dealt fairly with others or the subject.» The History of Geology is a matter of *facts* and dates, beginning in 1809, an epoch quite near, and therefore easily verified. I gave all the discoveries with the date at which they were made, as I believed truly and impartially; — if Mr. Dana thought I had dealt unfairly with «others and the subject», he had only to give facts and dates to show this, — but not at all; he contents himself with personal abuse, and says at the conclusion of the article that I have «*expunged names from American geological history.*» Happily for me, Messrs. Dana and Rogers published severally an *American Geological History*, in 1856, and it will be easy to show by comparison, who merits the charge of having *expunged names from American Geological History.*

Mr. Dana places Mr. B. Silliman Senior among the leaders of Geology in America, putting his name immediately after

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that of Maclure, the Father of American Geology. Mr. Silliman is certainly a friend and promoter of science; he was formerly a good lecturer on *popular* geology, and originated the *Journal of Science and Arts*, which he carried through the whole of the *first series* with much more ability, tact, and justice, than have been latterly shown in its management; but this does not constitute him a leader of American Geology, or give him a right to the second place among the discoverers.

Dana says: « Morton was the *first* to distinguish the North American *Cretaceous* beds. » This claim in favor of Morton is not only false and unjust towards the true discoverer Vanuxem, but against the printed opinion of Morton himself, who in several publications says: « Mr. Vanuxem was the *first* to distinguish the *Chalk* formation in America. » In Dana's history the name of Vanuxem is *expunged from among Cretaceous observers*, and also that of Conrad.

The exclusive credit given by Dana to James Hall and Henry D. Rogers for all that has been done on the Paleozoic strata of North America, calling their labors the «*keys*», «a standard of comparison for the whole country and even for the world,» is by far *too* exclusive; the *keys* possessed by these two geologists, if any they have, must be those of Vanuxem, Emmons, Conrad, Mather, Whelpley, Henderson, Lesley, Taylor, etc. I have shown by dates in my *Synopsis* the part taken by Hall and Rogers in the classification of the Ameriean Paleozoic strata, and although Mr. Dana may think they did the whole, their share in truth is *far below* that of Vanuxem, Conrad, D. D. Owen, Emmons, Taylor, de Verneuil, Troost, Safford, and Swallow.

Dana *expunges* from the investigators of Canada and the British Provinces *all the names of the first pioneers*, such as: Capt. Bayfield, Baddeley, Richard Brown, J. B. Jukes, Bonnycastle, and Gesner, imitating the example of Messrs. Logan and Hunt, who in their works on British America never give credit to anybody but themselves. For example I cite the following phrase. « Pour les faits géologiques et pour ce qui se rapporte à la structure physique du pays, *tout est dû à M. Logan*;

la minéralogie, ainsi que la chimie des roches métamorphiques et des eaux minérales sont les résultats des travaux de M. Sterry-Hunt, qui a rédigé ce mémoire.» See: *Esquisse Géologique du Canada*, by Logan and Hunt; p. 14. Paris, 1855.

Besides the names already given, Dana *expunges* from American Geological History those of Edwin James, Byrem Lawrence, Thomas Nuttal, Rafinesque, Godon, de Castelneau, Daniel Sharp, Yandell, Koch, Ducatel, Alexander, Booth, Tyson, Cozzens, Featherstonhaugh, Lieber, White, etc. etc., all which are given, with an account of their labors and discoveries, in my *Geology of North America*, and will show to the impartial reader who merits the accusation of «a partial acquaintance with the subject» and of having «*expunged names from American Geological History.*»

In a *History and Literature of Geological Research in the United States*, by Henry D. Rogers, names are *expunged* from American Geological History not only now and then, as it is the case with Dana, but they are swept out *en masse*, until there remain hardly any to support the two brothers Rogers, who seem to have performed by far the greater part of the researches themselves. For instance he *expunges* from the Paleozoic formations the names of Vanuxem, Conrad, D. D. Owen, Emmons, Mather, de Verneuil, Troost, Safford, Swallow, Tuomey, Norwood, etc., in fact all the names connected with these rocks, except Eaton, Taylor, Gesner, and Dawson. The name of Vanuxem is *expunged* as a matter of course from the history of the *Cretaceous* strata, as it is in Dana's account.

As for the New Red Sandstone formation, Mr. Rogers not only *expunges* all the names of geologists connected with it, but the rocks themselves, Permian, Bunter Sandstein, Muschelkalk, and Keuper, are *expunged* from American deposits.

Lastly Mr. Rogers *expunges* from the Tertiary formations the name of Dr. Leidy! and from the Quarternary and Modern formation the name of Agassiz!!

TRIASSIC ROCKS IN THE LAKE SUPERIOR REGION.— Mr. Dana says that my view as to these rocks is «the old

one and the only one current, until the *evidence* became known which Foster, Whitney, Hall, Logan, and others brought forward.» I beg Mr. Dana's pardon, but I find in «*Outlines of the Geology of Lake Superior*», by Capt. H. W. Bayfield, published in 1829, that this illustrious pioneer of Canadian geology synchronized the *Red Sandstone* of Lake Superior with the *Old Red Sandstone*, taking care at the same time to mention, that he thinks it older than the sandstone containing gypsum and salt of the northern part of New York (*Onondaga Salt Group and Medina Sandstone*). At that time the Silurian was undiscovered, and the Old Red Sandstone were the *oldest stratified rocks known*; so Bayfield evidently meant by his suggestion to say that the *Sandstones* of Lake Superior were the *oldest stratified rocks*, which Hall, Logan, Whitney, and Foster have given twenty years later as a *new opinion.*

NEW RED SANDSTONE AND JURASSIC ROCKS IN THE ROCKY MOUNTAINS. — The objections made by Mr. Dana to my observations on these formations consist of negations merely, no facts being adduced to invalidate my opinions. He admits that other geologists give facts as a basis for their conclusions; but mine are only «*hazardous guesses*», «*geological gymnastics*», and the «tests of equivalency» given by me, «science has long since repudiated.» In order to give more weight to his criticism, Mr. Dana has consulted an able palæontologist, «highly commended by me», one «who has facts as a basis for his conclusions, and who admits a doubt until it is fully removed by investigation.» The name of this able palæontologist is not given, but as he is said to be «*well* accquainted with the region beyond the Mississippi», it can be no other than Mr. J. B. Meek, whose personal acquaintance with «that part of the continent» is *not very extensive.*

Messrs. Hall, Meek, and Dana in the determination of the relative age of strata, admit only palæontological evidence, for them all geognostical characters must disappear before the test of fossil remains; *lithology* is good for nothing, and «an appeal to such characters in this period of geological science

betrays great want of experience», says Mr. Dana. «Knowing as we do that lithological characters are of no value whatever as a guide in drawing a parallel between these formations and those of the old world», say Messrs. Meek and Hayden; see: «*On the so-called Triassic Rocks of Kansas and Nebraska; Silliman's Journal*; Jan. 1859, vol. xxvii, p. 34. As for the *stratigraphical* characters, they do not even mention them. My way of observing, or *guessing* as they call it, is wholly different. I consider *stratigraphy* as the *first* of all the characters, and I spare no pains to ascertain it by direct and numerous observations; then come *fossil remains*, and lastly the *lithological* characters. I always try as far as possible to use these three different series of characters together, and when one or even two of them fail completely, I apply myself with more care to examine the one or two that remain. That is, I follow the method pursued by all practical geologists. I regard the stratigraphical characters, as I said above, in their full significance; superposition, discordance, inclination, direction, etc., as *superior* to the *two other series of characters*; then come the organic remains, and lastly the lithological characters, which are the least important, but still useful when considered by a geologist of great practical experience.

I will remark, by the way, that when Messrs. Dana, Meek, Hall, and Blake admit only the palæontological characters, and say «that the region I traversed was nearly destitute of fossils,» they take great care to reject the determination of the few fossils I was able to gather, saying «that they are not determined right» — notwithstanding their determination by de Koninck, de Verneuil, Agassiz, d'Archiac, etc. So if they admit the characters of fossil remains, it is with the curious and modest condition, that nobody else but themselves can rightly interpret them. It would have been much easier for these learned observers to say at once that I am not a geologist, and that they will pay no attention to my writings, than to deny my observations in detail as they have done.

I have already replied to the objections of Mr. J. B. Meek

as to my determinations of fossils, in a *Letter on some points of the Geology of Texas, New Mexico, Kansas, and Nebraska*, Zürich 1855, therefore I will now consider only the views which Mr. Meek did not think best to communicate to me in his letter of 22. Aug. last, declining my frank request for his opinion, on the ground that he had no time to study as carefully as he should wish my *Geology of North America.*

Mr. Dana was more favored; Mr. Meek tells him, that my *Spirifer striatus* var. *triplicatus* is the *Sp. cameratus* of Morton, — the figure and description of *Sp. cameratus* in *Silliman's Journal*, 1st series, vol. xxix, p. 150, are so imperfect that it is not possible to decide to what species that fossil belongs — and that my *Spirifer striatus* is not that species. I differ from Meek, Hall, and Morton as to the propriety of creating a species under the name of *Sp. cameratus* for that fossil, and I think, in accordance with de Koninck, who has investigated the subject, specimens in hand, that it is only a variety of the true *Spirifer striatus.* As for the *Sp. striatus*, fig. 2, pl. vii of my *Geology of North America*, I maintain that it is that species, not only from my own determination, but also from the determinations of de Verneuil and de Koninck. In speaking of my *Spirifer striatus* var. *triplicatus* Mr. Meek says that «he has no knowledge of its having ever been found in Lower Carboniferous rocks», and he repeats that assertion with regard to the *Terebratula Uta*, *Terebratula Mormonii*, *Terebratula subtilata*, etc., in his last publication entitled: *Geological Explorations in Kansas*, Philadelphia 1859. This may be the case wilh Mr. Meek, who places the *upper part of the Lower Carboniferous rocks* of the Far West *above* the *coal measures*, a mistake arising probably from the neglect of stratigraphical characters, but that does not prevent others from finding these fossils where I place them, *below* the *coal measures*, in the upper part of the Mountain Limestone. Further, Mr. Meek says: «There are many other American Carboniferous species set down as identical by Mr. Marcou and others (what does he mean by others?), but it is well knowm to American palæon-

tologists that the whole subject requires careful revision.» Mr. Meek, by referring this question to *American palæontologists*, seems to wish to create *national prejudices*, that happily do not exist in science; for geology does not recognize boundary lines of any kind, and *a Geologist, when among rocks, is always at home.*

Mr. Meek says: «We now know beyond *any reasonable doubt* that all the country from the Platte to the British Possessions, and from the Missouri to the Black Hills, is occupied by Cretaceous and Tertiary rocks.» As Mr. Meek is one, according to Dana, who «has facts as a basis for his conclusions, and who admits *a doubt* until it is fully removed by investigation,» I will remark that I regard his *Lower Cretaceous No.* 1, as not belonging to the Cretaceous at all, but as *Triassic, Permian, Jurassic*, and *Miocene*; that Meek and Hayden have completely overlooked the geognostical characters of what they call *Lower Cretaceous No.* 1, mixing the strata together without regard to stratigraphy, lithology, or even palæontology; and that there are many very *reasonable doubts* with regard to that part of their geological notions for the country north of the Platte river. Further, what Messrs. Hayden and Meek call *Miocene* of the Tertiary basin of White and Niobrara rivers (*Explanation of a Second Edition of a Geological Map of Nebraska and Kansas*, p. 13) is only *partly* Miocene, at least a good *half* of it is *Triassic* and even *Jurassic*; such are their beds C., D., and E. They will never succeed in persuading geologists acquainted with the Prairies of the West, that the Sand Hills between the Platte, Niobrara, and White rivers, and the mounds, columnar, and pyramidal masses of the Mauvaises Terres, are formed by strata of *Miocene* or *Cretaceous* ages.

Mr. Meek adds: «And as regards the region from the Platte southward to the Red river, very far the larger part is known to be *not* Triassic, while it is possible that the Trias may occur in some parts of it.» I can assure Mr. Meek from my direct and personal observations that the larger part of that region *is* Triassic.

«The surface formations of the Llano Estacado, says Meek,

instead of being Jurassic, are Cretaceous; this is *plain* from the section of Pyramid Mountain and also from numerous other facts collected by recent explorers.» Here, certainly, Mr. Meek does not admit «facts as basis for his conclusions,» for I am the *only geologist* who has visited Pyramid Mount, and from the section observed and described by me there *I am sure* that the surface of the Llano Estacado is Jurassic, and I can vouch for it with the same degree of certainty, that I can say the Jurassic forms the mountains around Salins in the Jura.

As for a «narrow *outcropping* belt of Jurassic along the east side of the Rocky Mountains,» and the «*underlying* and not overlying rocks» for the Jurassic, all this is only a supposition of Mr. Meek based on erroneous observations; I have seen with my own eyes the Jurassic strata an *overlying* rock, forming a large belt of one hundred miles at least on the eastern side of the Rocky Mountains.

If Messrs. Meek and Hayden had not relied so exclusively upon fossils, putting entirely aside the *stratigraphical* and *lithological* characters, they would probably have been more successful in determining the relative age of strata, and not be obliged to give such conflicting interpretations of their *Lower Cretaceous No. 1* and the *non-existence* of *Jurassic* and *New Red Sandstone rocks.*

JAMES' DISCOVERY OF NEW RED SANDSTONE IN THE PRAIRIES. — Mr. Dana does not admit the claim of Edwin James as discoverer of the New Red Sandstone in the prairies of the Rocky Mountain region, but *expunges* his name, without ceremony, from American geological history. He speaks of imperfections in my *Synopsis* «arising from a partial acquaintance with the subject and the science,» and continues: «Thus he (Marcou) speaks of Mr. E. James as having been the *first* to recognize the *New Red Sandstone* on the slopes of the Rocky Mountains, when all he had any knowledge of was *a red sandstone.*» Further, in rejecting my determination of the Triassic formation in the Rocky Mountains, Dana says:

«And as far as suggestion goes, that of James had long the *precedence.*» These are rather contradictory statements. The truth of the matter is, that Ed. James, vol. II of *Expedition to the Rocky Mountains under Long*, Philadelphia, 1823; p. 399, compares his *red sandstone* and *argillaceous or gray sandstone* to the *New Red Sandstone of English Geologists*; and more, he admits the false view of Mr. Weaver and others, considering it as *inferior to the coal strata*, and giving it that position in his *Vertical Section on the Parallel of Latitude* 35° *North*, *intended as a continuation of Maclures' fifth section*; (see: *Maps and Plates*).

I established Mr. James precedence with great pleasure, being enabled thus to rescue him from the «studied neglect» with which he had been previously treated.

NEW RED IN NORTH CAROLINA AND VIRGINIA. — In *Silliman's Journal*, vol. xxiv, second series, p. 428, the editor says: «Prof. O. Heer has carefully examined Prof. Emmon's «*North Carolina Report*, as well as specimens, and forwarded «his conclusions and corrections, which are now before me.» The truth is, that I gave to my friend Heer for examination *my own specimens*, *picked up by me in* 1849, in the Virginia coal field of Chesterfield county, at the same time putting into his hands all the publications on the subject by Emmons, Bunbury, W. B. Rogers, and R. C. Taylor; and that Heer sent me his conclusions and corrections, which were made for the benefit of my *Geology of North America*, then in press. Having mentioned this precious manuscript of Heer in a letter to Prof. Emmons, he requested a copy, on the ground of the immense interest he had in the subject. I complied at once with his request, being very far from supposing the information would be used in such a manner by the *Silliman's Journal*: that my name would be *expunged* from it.

GEOLOGICAL MAPS BY ROGERS, HALL, AND MARCOU. — «We know well,» says Dana, «that if any *American* geologist «had mapped out strata and synchronized those of America «and Europe, on such data as have satisfied the author of the «*Geology of North America*, he would have been deemed young

«in the science, with much yet to learn before he could have «a sober hearing.» Messrs. Henry D. Rogers and James Hall have «mapped and synchronized American strata,» *since* the publication of my *Geological Maps* in the two following works: *Geological Map of the United States and British North America*, 1856, and *Map illustrating the general geological features of the country west of the Mississippi river*, 1857. Future geologists can decide which of the three authors was «satisfied with the best data for mapping and synchronizing the American strata.»

AGASSIZ' REPLY.

On reading the criticism of Dana in the number of *Silliman's Journal* for November 1858, Agassiz sent the following answer:

On Marcou's „Geology of North America;" by Prof. Louis Agassiz.

(Extract from the *Silliman's Journal of Science*, second series, vol. xxvii, n° 79, p. 134 etc., January 1859.)

I have not yet seen Marcou's latest publication on American Geology, but I have now open before me, his paper in the Proceedings of the Geological Society of France, and that in Petermann's « Geographische Mittheilungen,» both bearing date 1855, as well as the Geological Map of the United States and British North America by H. D. Rogers, also bearing date 1855, and Hall's and Leslie's Map of the country west of the Mississippi river, published with the 1st vol. of Emory's Report in 1857. I take it that it will be no injustice to either Rogers or Hall to go to an earlier publication of Marcou's, in a comparison of their respective claims to correct illustration of our Western Geology. Let me premise by saying that as far as the geology of the East is concerned, from Iowa to the Atlantic coast, I acknowledge that to Hall is due, unquestionably, the credit of having settled by extensive comparisons, and by personal examinations, the true geological horizon of the vatest extent of our continent, not only by an examinaticn of the superposition of the rocks, but also by the most minute and most extensive study of the fossils.

We all know also how much the Rogerses have done to elucidate the physical geography, the orography, and the order of succession of the formations of Pennsylvania and Virginia, which has thrown much light upon the general geology of the eastern part of the continent. It is equally well known how much the special state surveys have added to the details in this general investigation of the Geology

of North America. But when we go west of the Mississippi valley to the Pacific shores the case is very different. The maps of Rogers, Hall and Marcou, are a compilation and an attempt at coordination of surveys which cover only a very small portion of the ground. They are, as it were, the reading of the authors of these different maps, of investigations made by others, though Marcou has here unquestionably the advantage of having gone himself over the ground.

A comparison for instance, of the manner in which the volcanic rocks are dotted over New Mexico, Sonora, and Lower California, as well as in California, Oregon and Washington Territories by Hall and Rogers, with Marcou's representation of the same cannot fail to show to a geological reader, that they are more natural in Marcou's map than in the two others. When a region is not more minutely surveyed than the whole western half of our continent, of which we have not even accurate geographical maps, it is not possible to expect accuracy in detail, and the critic must consider the general connection rather than special points.

I do not see, for instance, how the omission of State boundary lines which in a former review of Marcou's map in the Journal, was made a prominent objection to his representation of American geology, can be of any importance in such a general survey of the subject. Rogers in his map does not give these boundaries any more than Marcou.

But I now come to the essential point. What is the true geological character of those five hundred thousand square miles of land, extending between the Mississippi, west of Arkansas and Missouri, and the great Salt Lake Basin? Rogers colors it uniformly with Cretaceous rocks, and the well known Tertiary deposits, adding metamorphic rocks, flanked with Carboniferous in the mountainous tracts. Hall does the same only making in addition, a distinction between the upper and lower Cretaceous, while Marcou distinguishes further between Permian, Triassic and Oolitic beds. I do not suppose that he, any more than Hall and Rogers, imagines that the boundaries he assigns to any of these groups are any more accurate than those assigned by Rogers and Hall to the groups they distinguish. These appear to me simply in the light of the respective readings of isolated facts recorded in the way they have struck the authors of these different maps. When in his paper to the Geological Society of France, Marcou speaks of himself as a travelling geologist who «brings his little stone to the great edifice» (page 3) it does not appear to me as vain-glorious boasting, and we ought to take gratefully the contributions of a Frenchman, using language after the fashion of his nation, even though it be not the way in which we would have ex-

pressed ourselves. Now I confess that after reading the condensed Rewiew of American Geology which Marcou has given, in Petermann's Contributions, I find in it a more comprehensive account of the general features of the orography and geology of the Western half of our continent, than in the other representations I have read upon this subject. I think that even now a translation of that paper would be welcome to every English student of American geology, and that far from circulating false impressions, it would greatly contribute to bring before the mind the grand features of that remarkable country, and to connect in an intelligible way the geology of the West with that of the East. The middle tract of our continent is unquestionably occupied by deposits younger than the coal; I do not allude to the Lake Superior Sandstone respecting which I believe Marcou to be mistaken, — but the five hundred thousand square miles of questionable character as to the details, certainly belong to those from recent formations.

Now it appears to me that the geology of our Atlantic States furnishes data upon which theoretical inferences, bearing upon the question which Marcou's assertions call forth, may be founded. We know that the Cretaceous formations extend from the Atlantic slope of the Alleghany range round their southern spur into the great geological gulf now occupied by the Mississippi valley. We know further that along the eastern slope of the Alleghanies, beginning with the Connecticut valley, there extends, between the axis of elevation of that chain and the Cretaceous deposits at its Atlantic foot, a series of deposits referred respectively to the Triassic and the Oolitic series.

We know also that to the south of North Carolina, these lower secondary deposits are covered over by the Cretaceous. Now, since the upheaval of the Alleghanies is anterior to the deposition of the Trias, does it not appear natural to suppose that Triassic and Oolitic formations must have been deposited at the foot of the western slope of the Alleghanies as well as upon its eastern slope, and that the Cretaceous deposits overlap them in the Mississippi gulf in various ways, as along the Alleghany chain, and that, following various routes, the different geologists who have gone across the continent must have seen, here Trias, then Jura, and then again Cretaceous beds, overlaid by Tertiaries, in a number of points, already determined, though the relative extent of all these beds, over a surface of 500,000 square miles, remains yet to be ascertained.

The circumstance that Marcou has colored in yellow the whole middle tract of the continent, can express nothing but his conviction that the whole Mississippi gulf is lined with Triassic beds, overlaid with more or less extensive Jurassic, Cretaceous and Tertiary de-

posits. In such a theoretic representation of the geological features, where the details are wanting, provided the existence of the Trias and Jura is made out somewhere, there is no more inaccuracy than in coloring a map of our eastern geology, where the drift covers the greatest extent of the surface, as if it were altogether occupied by Paleozoic rocks.

I take it that such things are, by this time, understood by all those who examine schematic maps,—at least they should be. Moreover, the discoveries by Professor Swallow and Mr. Meek of Permian beds in Kansas, along the eastern border of the great Mississippi gulf, and by Professor Hall in Iowa, furnish a very unexpected confirmation of the broad statement first made by Marcou, that while the Eastern part of our continent consists of Paleozoic rocks, the middle part is occupied by the Mesozoic series. I truly believe that, at some future period, the general outline of our western geology by Marcou, which by the way, has the priority over the others, will stand before a complete survey of the whole in the same light as Maclure's old map now stands, when compared to the well-known eastern geology.

In this connection, I cannot but remember that, with Thurmann, Mandelslohe, Gressly, Quenstedt, Römer, d'Orbigny, and Oppel, Marcou is one of the geologists who knows the Jurassic formation best; that he has published a masterly paper upon the Jura Salinois in the Transactions of the Geological Society of France; and that it seems hardly credible to me that he should have been so completely mistaken in his identification of Oolitic beds in the west. I have myself, in my collection, a large number of specimens of the Cretaceous fossils of Texas and of New Jersey, among which is a beautiful series of the Exogyra, characteristic of the Cretaceous period, and I have seen the Exogyra and the Ostrea which Marcou brought from his excursion across the continent, and I distinctly remember that I could not identify them with the Cretaceous species, but rather thought them allied to Jurassic species.

Whoever has read Marcou's paper on the Jura must have seen that he knows, as well as any geologist living, that lithological characters are of no value in identifying geological horizons. But after having presented the general evidence, as far as it goes, for the presence of Triassic and Oolitic beds in the middle tract of our continent, I cannot find that there is any reason for blame, with his familiarity with the Triassic and Oolitic rocks of Europe, in his pointing out the lithological resemblance there may be between them, any more than there is ground for blaming the American geologists who, after identifying certain beds in New Jersey as Cretaceous, have

also alluded to their mineralogical resemblance with the Green Sand of Europe; for this is, after all, a remarkable fact which runs over immense tracts of geological deposits belonging to the same horizon.

Mr. Dana's love of the *truth* and *duty to science* obliged him to decline publishing this article in my favor without alterations, which the author refused to make, not wishing to pass under Mr. Dana's editorial scissors, and Mr. Agassiz was obliged to threaten the withdrawal of his name from the *Journal*, to induce Mr. Dana to modify his views of duty sufficiently to publish the article as it was written. He consoled himself however by *reviewing* Mr. Agassiz on the *very next page*, as follows:

Reply to Prof. Louis Agassiz on Marcou's „Geology of North America;"

by James D. Dana.

(Extract from the *Silliman's Journal*, second series, vol. xxvii, n° 79, page 137, January 1859.)

I regret in such a case as this to have to differ from Professor Agassiz. The amount of difference is however not as great as at the first reading may appear; for an important part of the positions in my paper are untouched, and an explicit dissent from some of the views of Mr. Marcou is expressed.

The statements in Professor Agassiz's remarks to be especially noted are the following:

1. That Professor Agassiz had not read the work reviewed, but had seen the earlier papers by Mr. Marcou and examined his geological map.

2. That while, as regards the geology of the East from Iowa to the Atlantic coast, «to Mr. Hall is due unquestionably the credit of having settled by extensive comparisons and by personal examinations the true geological horizon of the vatest extent of our continent, not only by examination of the superposition of the rocks, but also by the most minute and most extensive study of the fossils;» and that while the «Professors Rogers have done much to elucidate the physical geography, the orography, and the order of succession of the formations of Pennsylvania and Virginia, and have thrown much light upon the general geology of the eastern part of the Continent,» — west of the meridian of Iowa their observations have not extended, and Marcou has thence the advantage of them.

3. That the maps of the region west of the Mississippi by Rogers, Hall, and Marcou are mainly compilations from the results of various

surveys, and that Marcou in extending the colors of the Triassic formation over the 500,000 square miles of the Rocky mountains, and laying down also the Permian and Jurassic over the same region, was no more culpable than Hall or Rogers in covering it with Cretaceous.

4. That Marcou is mistaken in regarding the Lake Superior Sandstone as Triassic.

5. That it is hardly credible that Mr. Marcou should have been so completely mistaken in his identification of Oolitic beds in the west; and that the two species collected by Marcou from the beds are most allied, in Professor Agassiz's opinion, to Jurassic species.

6. That Mr. Marcou knows that lithological characters are of no value in identifying geological horizons; and that adding these characters to other general evidence for the Triassic and Oolitic rocks is not blameable.

The claims which Mr. Marcou has put forward in his work are: (1) the correct determination of the Red Sandstone of the Lake Superior region; (2) the identification, for the first time, of the Permian over the Rocky Mountain region; (3) the same, of the Triassic; (4) the same of the Jurassic. I have presented evidence proving, as I believe, that he was wrong in each case; and hence, that the claims of prediscovery which he is now urging over Europe are groundless. Besides this, I have pronounced the work abusive of such men as the Rogerses, Hall, Whitney, Logan, Hunt, and many others, and grossly unjust to American science and geological history, while full also of groundless personal claims. I review some of these points.

Supposed Triassic of Lake Superior.—Prof. Agassiz admits that he believes Mr. Marcou to be wrong with respect to the Triassic («New Red») character of the Lake Superior Sandstone, and thus we do not differ as to this one of the claims.

Now this question of the Lake Superior Sandstone is the one that especially calls out Mr. Marcou's opinions of American geologists. Making these rocks, and the Connecticut river and Virginia beds, as well as 500,000 square miles of territory over the Rocky Mountains, «New Red,» he is indignant that Hall, Whitney, Logan, Professor Rogers, etc., do not follow in his track. After giving a one-sided view of opinions on the different rocks which he classes together as *undoubted* «New Red» he says:

«In accord with the geologist James Hall, the brothers Rogers refer all the *Red Sandstone Formation* along the Atlantic slope (see: *Geological Map of the United States*, by Henry D. Rogers, page 32; in the *Physical Atlas of Natural Phenomena*; Edinburgh, 1856) to the Jurassic epoch. Their opinion, however, is not explained by H. D. Rogers in a very clear and concise manner. In page 29, he says

positively «*Jurassic*; represented in Virginia and North Carolina by a group of bituminous coal-measures, and in the valley of the Connecticut and on the Atlantic slope, from the Hudson to North Carolina; and again, in Nova Scotia and Prince Edward Island, by belts of a red shale and sandstone. *Triassic* and *Permian*, not represented by any known American deposits;» and in page 32 Rogers says: «the Continent (North America) embraces an extremely small extent of the Older Mesozoic or *Triassic and Jurassic* formations.» Further; «Geographical distribution. — Commencing at the North-East, the first tract of *Triassic or Jurassic* red sandstone, etc.» I call the attention of the reader to the expressions first Triassic *and* Jurassic, and next Triassic *or* Jurassic; *and*, *or*, are two different words. A few lines further on he says: «The red rocks of Prince Edward Island pertain probably to both the Coal period and to the *earliest Jurassic*, etc...»; and also: «The vegetable fossils in the Connecticut sandstone, display such alliances with those of the *Jurassic* coal rocks of Eastern Virginia as to place the *early Jurassic* or *late Triassic* age of the deposit beyond a question.» — Is Keuper *early Jurassic?* or Lias *late Triassic?* the author is silent on these two questions. — And also « . . . in the *Liassic* coal rocks of Eastern Virginia, etc. . . .»; also «The few organic remains hitherto procured from this Carolina (Deep River) coal field are identical with forms found either in the Virginia *Jurassic* coal strata, or in the Virginia Middle Secondary red sandstone, of *nearly coincident Jurassic date*».»

«It is difficult to present an age of strata in a manner more ambiguous and *empatée*. *The brothers Rogers and James Hall try their best to suppress* the New Red Sandstone formation in North America; but they do not know exactly what to do with these five or six thousand feet of strata. On the Geological Map of H. D. Rogers, the New Red Sandstone is unknown in the Magdalen Islands; on the north-east of the Baie des Chaleurs it is colored as Jurassic Red Sandstone, though the *Honorable Sir William E. Logan*, *Chevalier of the Legion of Honor*, calls it Carboniferous Sandstone. In Prince Edward Island, Connecticut valley, New Jersey, Pennsylvania, Maryland, Virginia and North Carolina, the New Red is colored as older Mesozoic (Jurassic coal and Jurassic red sandstone). In Lake Superior it grows older, and the New Red is colored Cambrian, (Primal, Auroral and Matinal). In the Praries, Texas, Rocky Mountains, New Mexico, etc., the «New Red,» that seems to change its age with Protean facilility, has once more renewed its youth and is colored as Cretaceous, and sometimes also as umbral and vespertine, or in ordinary language as Lower Carboniferous.»

«*They have not thought of putting the New Red in the Upper Silurian*

or the Tertiary. I would advise these honorable savants to consider if one of these determinations would not be preferable.»

The *jumble* here is of Mr. Marcou's making, and it comes of his own errors about the «New Red.» We let the style of criticism go without remark, satisfied for the present with italicizing only some of the more characteristic parts.

While on this topic, Mr. Marcou, noticing that Dr. D. D. Owen had within a few years taken the same ground with Prof. Hall and other geologists, says, «why Owen changed his views is quite a mystery.» He will now regard the case of Dr. Owen not the only mystery.

Permian of the Rocky Mountain Region. — I pointed out in my review that Mr. Marcou had distinguished as Permian, rocks that contained fossils which he set down in his *Field notes* and *Résumé* with a query as a *Belemnite* and a *Pteroceras* (the latter word changed in the recent work to *Gasteropod*), although no Belemnite or Pteroceras is known to occur below the lower Jurassic (Lias). Disregarding or defying the hints from the imperfect fossils, he made the beds Peron *lithological characters* and superposition alone.

On the Permian of Mr. Marcou, Prof. Agassiz says nothing. The use made of lithological characters in its determination is far from sustaining the opinion cited above in paragraph 6.

Triassic of the Rocky Mountains. — My review states that Mr. Marcou established the existence of the Triassic on one fossil, and that an uncertain species of pine wood: this one doubtful fossil wood, and the *lithological characters* make up the evidence in favor of the discovery: and on *lithological characters* and superposition alone he based his queried subdivision of it, into *Bunter*, *Muschelkalk*, and *Keuper* — thus again badly misusing lithological evidence. He mentions also the discovery of a *Cardinia*, but says that Cardiniæ occur in rocks from the Jurassic to the Carboniferous.

Professor Agassiz brings forward nothing against my conclusion that the Triassic was not identified in the Rocky Mountains by Mr. Marcou.

Jurassic rocks in the Rocky Mountains. — The evidence which I cited that Mr. Marcou's Jurassic is really Cretaceous, was based on the determination by Hall, Conrad, Shumard, and others, that his supposed Jurassic fossils are Cretaceous, and that they occur at localities in the west along with known Cretaceous species. Morton's figure of the *Gryphea Pitcheri* (Morton) I understand was made by Conrad, so that Conrad is certainly good authority as to the identity between it and Mr. Marcou's species. Dr. Newberry, who has recently returned from the Rocky Mountains confirms these conclusions; for he says (see this volume page 33):

«I may say in confirmation of the assertion that your fossil plants [species of Alder, Beach, Credneria, Ettingshausinia, etc.] are Cretaceous, that I found near the base of the yellow sandstone series in New Mexico, considered Jurassic by Mr. Marcou, — a very similar flora to that represented by your specimens, one species at least being identical with yours, associated with *Gryphea*, *Inoceramus*, and *Ammonites* of lower Cretaceous species.»

With such evidence, even the exact identification of the two fossil shells is of little importance. The Cretaceous is the lowest formation in which leaves of any dicotyledons have been found.

Professor Agassiz states that Mr. Marcou is a good Jurassic geologist. But this does not affect the case in hand. For he had but two or three fossils about which to use his Jurassic judgment; and if this judgment has pronounced fossils to be Jurassic that really occur in the west associated with Cretaceous species, or if his knowledge of rocks in Europe has led him to think he can tell Permian, Triassic, or Jurassic rocks by their lithological characters, when he sees them in America, it has served him badly.

We regard it therefore as still true that Mr. Marcou's Triassic of Lake Superior, is not Triassic; and in the Rocky Mountain region, his Permian is not proved to be Permian, his Triassic not Triassic, and his Jurassic not Jurassic. Where are then his discoveries?

Map. — As regards the geological map-making, there is little resemblance between the cases of Rogers and Hall and Mr. Marcou. The former do not claim to be discoverers over the Rocky Mountain region, and Mr. Marcou does. Mr. Marcou, while remarking that the colors to the north and south of the course he followed are only approximative, says, «*I am sure of the limits of the formations on the line I have explored near the 35th parallel of latitude*;» and guided by this *sure* determination, he marked the Triassic on his map, and then, at a hazard, influenced by his views of earlier explorations, he spread the Triassic color far north over the 500,000 square miles. Now if his identification of the Permian and Triassic was in each case an error, what shall we say of the 500,000 square miles? and what of his map, if this is all wrong, and in addition his identification of Triassic in the Lake Superior region? He cannot rightly shield himself behind any geologist, or the common usage of following the best compiled results for fixing the lines.

Theoretical inferences may be good by way of suggestion; but too eagerly followed they lead to just the errors Mr. Marcou has made. But his system for the West has not even the show of probability in its favor. It is well known, and Mr. Marcou admits it, that Cretaceous fossils and rocks occur about the very summit plains of the

Rocky Mountains. The natural inference is, therefore, that when in Cretaceous times these summits were under water, the sea also extended over what are now the eastern slopes of the mountains, and might have covered them with Cretaceous beds; and that thus the Cretaceous should be expected to be the surface formation, (it is understood that the question relates to the *surface* formation, as the colors refer in all cases to this,) and that any Jurassic, Triassic, and Permian, if they exist, should be covered by it. This, I say, is what should naturally be expected. Moreover, this is what all researches since Mr. Marcou was over the region are tending to prove; they sustain Hall and others in coloring the greater part of the Rocky Mountain slope Cretaceous. The inferior beds, as the Palæontologist quoted from in my paper states, may be looked for as outcropping beds about the base of the ridges or crests of the mountains. Mr. Marcou's map is hence not only at variance with recent researches, but also with reasonable views of western geology.

We cannot see therefore that Mr. Marcou's claims as a discoverer are in any one case sustained, or that his merits are in any respect enhanced by his American researches. And we certainly should not go to him for an exposition of American geology.

Professor Agassiz knows well our American geologists and appreciates their labors; and he writes about them in a different style from Mr. Marcou. But on this point it is not necessary to dwell.

As to this last attack I have only a word to say. — First: Mr. Dana thinks Agassiz' difference of opinion as to the age of the Lake Superior Sandstone will be a *mystery to me*. But we visited Lake Superior together in 1848, and have often since discussed the question without being able to agree, a difference of opinion that each is willing to allow the other, however strange it may seem to Mr. Dana. Secondly: Mr. Dana speaks repeatedly of my ill treatment of the *American Geologists*, and as this may create a prejudice against me I will say, that *I honor and respect* the labors of American Geologists, as I think I have shown in my *Geology of North America*. But because my views differ from those of Messrs. Hall, Rogers, Blake, Logan, Hunt, Meek, Whitney, Foster, and Dana, is no reason for their *speaking in the name of the American Geologists*. Besides, I have never considered the accident of birth as having any relation to geology, and I have not

enquired, if H. D. Rogers of Glasgow is a Scotchman, or Mr. Dana a native of Buncombe, if Hall is a subject of the Pope, or Logan an Englishman; for these matters have nothing to do with their geological opinions and views.

It is almost needless for me to repeat that *I maintain my observations to be rigorously exact.*

The arrogant tone of superiority assumed by Mr. Dana is unfortunately but poorly adapted to «fully persuade» his readers as he desires. To accomplish this object the merits of my *Geology of North America* should have been calmly considered, and its unworthiness have been proved by facts and dates. As it is, I have good hope that the highly seasoned articles of Dana relieved by the remarks of Agassiz, may serve to stimulate the appetite of the impartial geological reader, to discover for himself where the *truth* lies, and I cheerfully leave the result to his decision.

Zurich (Switzerland), March 1859.

LETTRE RELATIVE A LA PUBLICATION DES NOTES DE SON EXPLORATION DES MONTAGNES ROCHEUSES ET DE LA CALIFORNIE;

par JULES MARCOU.

(Extrait du *Bulletin de la Société Géologique de France*, 2e série, tome XV, p. 533, seance du 17 Mai 1858.)

M. Delesse présente, de la part de M. J. Marcou, un ouvrage relatif à la géologie de l'Amérique du Nord (*Geology of North America*); il donne ensuite lecture de la note suivante qui lui a été adressée par M. Marcou.

Zurich, le 20 avril 1858.

La Société géologique de France ayant eu l'extrême obligeance d'insérer, dans les tomes VI, VIII, XI et XII de la 2e série de ses *Bulletins*, la plus grande partie de mes observations sur l'Amérique du Nord, je viens aujourd'hui, en lui offrant un exemplaire de ma *Geology of North America*, la prier de m'ouvrir encore ses colonnes pour une petite protestation.

Par suite de circonstances complétement indépendantes de mon libre arbitre et de ma volonté, et qu'il me serait pénible d'être obligé de rappeler ici, les deux cahiers de notes géologiques que j'avais écrits pendant mon exploration des montagnes Rocheuses et de la Californie, et la plus grande partie de mes collections, m'ont été enlevés de force, et remis, sans ma participation, entre les mains d'un nommé William P. Blake, de New-Haven (Connecticut). Cette personne m'ayant écrit de son propre mouvement pour me consulter *officieusement* sur l'opportunité qu'il y aurait de publier ces deux cahiers de notes *tels qu'ils étaient*, je me suis opposé à cette publication en m'appuyant: 1° sur ce que ces notes étaient écrites au crayon, en abrégé, avec beaucoup de signes conventionnels et en langue française; 2° sur ce qu'il y avait des parties à retrancher; 3° sur ce qu'il y avait beaucoup à ajouter pour les rendre compréhensibles; 4° et enfin sur ce que, ne connaissant pas lui-même la route que j'avais parcourue, il ne pouvait pas suppléer par sa propre expérience à des notes qui ne pouvaient être compréhensibles qu'à celui même qui les avait prises. En même temps, j'ajoutais: 1° qu'il pouvait publier un rapport en forme de *Résumé*, que j'avais adressé au commandant de notre expédition en juillet 1854; 2° que ma collection était en bon état, et que je ne voyais aucune objection à ce qu'il en donnât une description détaillée, aux deux conditions toutefois qu'il préviendrait que j'étais étranger à cette description, et qu'il ne ferait pas décrire les fossiles par James Hall, d'Albany.

Comme M. Blake me disait dans sa lettre qu'il aurait égard à mes désirs, et que c'était seulement pour assurer la publication officielle des résultats géologiques auxquels j'étais parvenu qu'il avait consenti à entreprendre ce travail, j'ai été fort surpris de voir que, non-seulement M. Blake n'a eu égard à aucun de mes désirs, mais bien plus qu'il a fait tout ce qui dépendait de lui pour annuler mes observations et nier mes découvertes; et je suis aujourd'hui à me demander quels sont les motifs qui ont pu pousser M. Blake à m'écrire une lettre, dont il avait évidemment pris la résolution d'avance de fausser tous les termes.

Une première publication des résultats principaux des diverses explorations pour l'établissement d'un chemin de fer entre la vallée du Mississippi et la Californie à été faite à Washington, en 1855, dans le format in-8, avec atlas in-folio. Dans ces rapports se trouvent deux mémoires avec ma signature; ce sont: 1° *Résumé of a Geological reconnaissance extending from Napoléon at the junction of the Arkansas with the Mississippi, to the pueblo de los Angeles in California*; 2° *Geological notes of a survey of the country comprised between Preston, Red river, and El Paso, rio Grande del Norte.* Ces deux mémoires, qui

ont été en grande partie publiés dans les tomes XI et XII du *Bulletin de la Société géologique*, renferment, avec des détails suffisants pour les mettre hors de doute, tous les résultats auxquels j'ai été conduit par mes recherches géologiques. Cette publication, in-8, a été limitée à un petit nombre d'exemplaires, à peu près trois cents, et pour l'usage exclusif du Congrès américain.

Depuis lors, une seconde publication, dans le format in-4, avec illustrations, etc., a été entreprise et se trouve aujourd'hui dans le commerce. Le tirage est de 11,000 exemplaires, et depuis 1856, sept gros volumes ont déjà paru. Le volume II contient le *Report near the thirty-second Parallel of North Latitude*, *from the Red river to the Rio Grande*, par le capitaine John Pope. Dans ce beau travail, Pope cite exclusivement mes notes géologiques sur son voyage, spécialement dans son chapitre VI, au sujet des puits artésiens à établir sur le Llano Estacado. Par une partialité que je suis loin d'attribuer au capitaine Pope, car je sais qu'il a fait tout ce qui lui était possible pour empêcher l'injustice dont j'ai été victime, on a omis complétement mes *Geological Notes* sur cette exploration, et à leur place on trouve un *Report on the Geology of the route*, par William P. Blake. Dans ce travail, M. Blake ne parle de mes *Geological Notes* que pour dire que je me suis trompé sur l'existence: 1° du *jurassique* qui pour lui est du *crétacé*; 2° du *trias* qui pour lui est en partie du *crétacé*, en partie du *carbonifère*, et en partie une époque géologique inconnue qu'il nomme avec beaucoup de sagacité *gypsum formation*, et enfin que ma suggestion, relativement à la possibilité de percer des puits artésiens à de grandes profondeurs, sur le Llano Estacado, est une impossibilité et une utopie. M. Blake a le talent de remplir une page in-4 avec ce que d'autres ont le défaut de dire dans une seule ligne, et son rapport au capitaine Pope n'est rien autre qu'une *compilation* déguisée, fortement étendue, et surtout torturée de mes *Geological Notes* de l'édition in-8, compilation qu'il n'avoue pas, et qui explique suffisamment le rejet de la publication, dans cette édition in-4, de mes *Geological Notes.*

Le volume III est exclusivement rempli par les rapports de l'expédition du capitaine Whipple dont j'ai été le géologue. J'aime à rappeler ici les relations amicales et d'intimité qui n'ont cessé d'exister entre Whipple et moi, depuis le jour où nous nous sommes réunis sur le pont d'un bateau à vapeur, au fort Smith, et les efforts de toute espèce qu'il a bien voulu faire pour m'assurer la publication du rapport géologique complet de notre expédition. Si ses persévérantes démarches n'ont pas été couronnées de succès, du moins il a fait tout ce qui lui était possible, et je sais qu'il ne s'est arrêté que devant une volonté supérieure et devant laquelle un militaire est

toujours obligé de fléchir. Je ne l'en remercie pas moins de ses nobles efforts qui se sont continués du reste jusqu'à la fin de la publication de ce volume III, et qui ont fini par faire insérer dans la dernière feuille du volume, après un premier rejet assez brutal, mon *Résumé* de l'édition in-8. Je suis heureux de pouvoir citer ici cette phrase d'une lettre qu'il m'a adressée dernièrement en m'envoyant ces volumes: «J'espère qu'en parcourant ces volumes vous vous »apercevrez que j'ai essayé qu'on ne vous fît pas d'injustices. Mon »opinion est que vos ennemis, par leur conduite, se sont nui à eux-»mêmes dans l'estime du monde scientifique.»

Un tiers du volume III est rempli par le ***Report on the Geology of the route***, rapport divisé en deux parties: le n° 1 ou ***General Report upon the Geological collections***, par William P. Blake, et le n° 2 ou ***Résumé and field Notes***, par Jules Marcou. Je prie tous les géologues de considérer mon nom comme effacé du rapport n° 1, où M. Blake s'en est servi presque à chaque phrase pour nier, annuler ou mutiler mes observations; je ne reconnais rien dans ces dix chapitres par Blake et James Hall comme provenant de moi. Quant au prétendu ***Itinéraire géologique du fort Smith et de Napoléon (Arkansas) au Rio Colorado de Californie***, original par Jules Marcou et traduction anglaise par William P. Blake, qui se trouve dans la partie n° 2, je déclare que ce document n'est pas de moi, et que M. Blake, en le publiant contre ma volonté expresse, à commis un acte d'indélicatesse sans exemple jusqu'à présent en géologie.

Je ne parle pas de la carte géologique et du profil exécutés par M. Blake, d'après, dit-il, les notes et collections de M. Jules Marcou: les cartes géologiques et le profil que j'ai publiés dans dans le ***Bulletin de la Société géologique*** et dans ma ***Geology of North America*** répondent suffisamment à ces productions que je ne considère pas comme sérieuses. La seule partie de ce n° 2 et de tout le volume III que je reconnaisse comme étant de moi est le ***Résumé of a Geological reconnaissance***, etc., et les citations que mon ami le capitaine Whipple en fait dans ses divers rapports; car je rappelle ici avec plaisir que ni Whipple ni Pope n'ont fait usage dans leur rapports des résultats et des rédactions de M. Blake: toutes leurs citations géologiques, minéralogiques et paléontologiques sont empruntées ***exclusivement*** à mes deux mémoires.

Je regrette d'être obligé de présenter une pareille protestation; mais un géologue pratique ne possède que sa réputation d'observateur, et mes adversaires ont fait tout ce qui dépendait d'eux pour la ruiner.

J'ai essayé dans les limites de mes forces et de mes faibles talents de faire mon devoir; et il est triste, surtout après avoir comme

moi perdu sa santé par les fatigues de toutes sortes que j'ai eu à supporter pendant mes voyages, de se voir, non seulement privé de la récompense de la publication officielle de ses recherches, mais bien plus de voir que la personne qui a eu la mission de les publier s'est appliquée, avec un courage peu enviable, à torturer, dénaturer et nier même des observations qui m'ont coûté les plus rudes fatigues auxquelles un géologue puisse être soumis.

NOTES

ON THE

CRETACEOUS AND CARBONIFEROUS

ROCKS OF TEXAS.

By JULES MARCOU.

[From the Proceedings of the Boston Society of Natural History, Vol. viii, January, 1861.]

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NOTES

ON THE

CRETACEOUS AND CARBONIFEROUS

ROCKS OF TEXAS.

By JULES MARCOU.

A short time after my last return to Boston, June, 1860, I received two memoirs by Dr. B. F. Shumard, *On the Geology of Texas*, in which that eminent paleontologist has expressed opinions differing from those published by me several times from the year 1854 to 1859. From the nature of Dr. Shumard's memoirs, which contain only short notices, without descriptions or figures of the contested species of fossils, without geological maps, and without real sections of the rocks identified, I did not intend to give my views on the subject, especially after having repeatedly explained the stratigraphical relations of the rocks west of the Mississippi.

In the mean time I wrote a letter, in September, to Dr. Shumard, telling him that although his memoir *On the Cretaceous Strata of Texas* was very interesting, I could not agree with him as to the succession given by him in his theoretical section, but that I hoped one day we might meet, perhaps at Fort Washita, or even at Pyramid Mount, and then settle amicably together our different views. Dr. Shumard

did not answer my letter, and I supposed, from his silence, that he was content to leave the matter as it was, until further researches were made; but Mr. Meek having called the attention of the readers of *Silliman's Journal*, vol. XXXI. Jan. 1861, p. 127, to the views of Dr. Shumard in opposition to mine, and taken special care to indorse his own previous opinions and those of his friends and collaborators, Messrs. James Hall, Dr. Hayden, and Drs. Shumard and Newberry, on the disputed geological age and order of succession of the strata in the West, I must once more try to disentangle the thread that my learned adversaries endeavor to keep in a constant imbroglio, and state again what I candidly suppose to be the truth, taking for a basis my own observations.

In the *First Report of the Progress of the Geological and Agricultural Survey of Texas*, December 1, 1859, Dr. B. Shumard says: "Mr. Marcou, in his *Carte Géologique des Etats Unis*, has attempted to define the limits of our coal measures. But the boundaries laid down by him are incorrect, and liable to lead to serious error. The coal measures do not extend into Grayson, Fannin, Collin, and Dallas counties, as represented in that map."

If Dr. Shumard will reduce a map of Texas, containing the county boundaries, to the very small scale of my *Carte Géologique des Etats Unis*, he will see that I have not placed any coal measures in Grayson and Fannin counties, and it is doubtful if I have put any into Collin and Dallas counties, for one or two lines will easily take out a county on such a reduced scale. On such a map, colors can only give a general idea of the distribution of the principal groups of the sedimentary and crystalline rocks. Geological landmarks must be looked for there, and not the geological details of the counties. In my first geological map of the United States, published in Boston, 1853, I showed the union of the coal fields of Missouri and Iowa with that of Arkansas, which Mr. James Hall said, in the *Silliman's Journal* of March, 1854, was "without authority," p. 205, vol. XVII. It is true that Mr. Hall himself united these coal fields in 1857, in his *Geological Map of the Country west of the Mississippi*, and Mr. H. D. Rogers did the same in 1856, both of them copying me, and I suppose sustained by good authority.

During my exploration of Arkansas and the Choctaw and Chickasaw countries in 1853, I perceived that the coal measures must extend into Texas; and from the collections of Capt. Pope, submitted to me at Boston in 1854, on his line of exploration from Preston to El Paso, by Fort Belknap, I concluded that the coal field did not stop in Arkansas, but extended into Texas as far as the Clear Fork of the Rio Brazos west of Fort Belknap. Aided by the observations of Dr. Roemer on the Rio San Saba, published by that learned geologist in

1849, I extended the coal field from Iowa to the vicinity of the Rio San Saba, expressing that opinion which I continue to think a true one, by a general outline, without any claim to the exact correctness of the boundary line, except near the thirty-fifth parallel of latitude, where I have seen the exact limits. From the collections submitted to me, I judged that the cretaceous rocks overlie and even conceal from view the carboniferous rocks on both sides of the Red River, near Preston, as shown on my map; and if my limit is too far south by one line or a fraction of a line, bringing the carboniferous into Collins and Dallas counties, I am much obliged to Dr. Shumard for correcting my mistake, but cannot see that my approximative limit is *liable to lead to serious errors*, as he thinks, on this account. A glance at the *Geognostische Karte von Texas*, published in 1849, — the only one then in existence, — in comparison with my map, will show the difficulties to be surmounted, in the modification and enlargement, made by me, especially as I had only been in the northern corner of the State, near the River Canadian, a hundred miles distant from Red River, and was obliged to make out the Triassic and Jurassic age of rocks, then and at this time considered as cretaceous by Messrs. Shumard, Meek, and Hall.

The second memoir of Dr. B. F. Shumard, alluded to at the commencement of this note, is entitled *Observations upon the Cretaceous Strata of Texas*. (See *Trans. of the Acad. of Science of St. Louis*, vol. I. p. 582. 1860.)

In this memoir Dr. Shumard describes a theoretical section, showing the order of succession of the different subdivisions of the Texan Cretaceous System, so far as his observations go, and correct in the main, he believes, although he admits that "further researches may render some slight modifications necessary." The various groups of strata, in regard to their statigraphical relations and fossils, were "investigated very carefully," he says, and adds, "We have devoted special attention to the *inferior division* of the system." Yet in the description of the *lower cretaceous*, he admits that he is indebted to his brother, Dr. G. G. Shumard, for a knowledge of it, and in the description of its different subdivisions, he seldom gives the strata which overlie or underlie them.

The tabular view of the strata given by Dr. Shumard is here given: —

Section of the Cretaceous Strata in Texas. By Dr. B. F. Shumard.

		Feet.	Characteristic Fossils.
Upper Cretaceous.	Caprina Limestone,	60	Caprina, Cytherea, and Ammonites.
	Comanche Peak group.	300 to 400	Exogyra Texana, Gryphœa Pitcheri, Janira occidentalis, Cardium multistriatum, C. Texanum, Pholadomya Sancti-Sabæ, Lima Wacoensis, Ammonites acuticarinatus, A. Pedernalis, Scolaria Texana, Phasianella tumida, Nerinea acus, Toxaster Texanus, Holectypus planatus, Cyphosoma Texana, and Diadema Texana.
	Austin Limestone. (Fish-bed.)	100 to 120	Gryphœa vesicularis, Exogyra costata, Ostrea anomiæformis, Radiolites Austinensis, Nautilus DeKayi ?, Baculites anceps, Hemiaster perastatus. Lamna Texana, Corax heterodon (falcatus), Mosasaurus.
	Indurated blue Marl, or Exogyra arietina Marl.	60	Exogyra arietina, Gryphœa Pitcheri, Janira Texana, Dentalia.
	Washita Limestone.	100 to 120	Gryphœa Pitcheri (*common var. and var. G. Tucumcarii*), G. sinuata, Marcou (*not Sowerby*), Ostrea subovata (*O. Marshii, Marcou*), O. carinata, Janira Texana, Inoceramus problematicus, Ammonites Texanus, A. Brazoensis, Hamites Fremonti, Nautilus Texanus, Holaster simplex, Toxaster elegans.
	Blue Marl.	50	Inoceramus problematicus, Ostrea, Plicatula, scales and teeth of fishes.
	Caprotina Limestone.	55	Orbitolina Texana, Panopœa Newberryi, Cardium Brazoense, Arca Proutana, Phasaniella perovata, Nerinea, and Caprotina Texana.
Lower Cretaceous.	Arenaceous group. .... (Fish-bed.)	80	Ostrea congesta, O. bellarugosa, Lucina, Plicatula. Lamna Texana, L. compressa, Ptychodus mammilaris, Galeocerdo pristodontus.
	Marly clay, or Red River group.	150	Ammonites Swallovii, A. Meekianus, Ancyloceras annulatus, Scaphites vermiculus, Baculites gracilis, Cytherea Lamarensis, Nucula Haydeni, Corbula Graysonensis, Inoceramus capulus.

I hope Dr. Shumard will pardon me for disagreeing with his views; and I recognize with pleasure, with Mr. Meek, that his exploration in Texas makes his memoir an important one, "entitled to great weight." He gives freely his opinion on my Pyramid Mount section,

and I trust he will allow me the same liberty with regard to his theoretical section.

The *Caprina limestone* is intimately united to the *Comanche Peak group*, forming generally the highest elevation on the table-land of Texas. Directly below, is what Dr. Shumard calls the *Comanche Peak group*. Comanche Peak is a celebrated landmark in Johnston County, and as the author has given this name to a special group of rocks, it would have been desirable to have a section of it, but Dr. Shumard gives a section of Shovel Mountain, in Burnet County, fifty miles distant. The Shovel Mountain section is divided into seventeen numbers, comprising three slopes, that is to say, three portions of the mountain where the strata are concealed from view. The *Exogyra Texana* is found near the summit, and the *Gryphœa Pitcheri* near the base; the whole thickness of the section is 355 feet. The list of fossils is given without regard to the subdivisions of the strata, and no one of these fossils indicates the upper portion of the Upper Cretaceous, either in America or Europe. Some of them, such as *Gryphœa Pitcheri*, *Ammonites Peruvianus* (*acuto carinatus*), *Am. Pedernalis*, *Nerinea acus*, and *Toxaster Texanus*, are forms indicating the Neocomian group of Europe, and I should not be surprised if these forms were all found together at Shovel Mountain in the same subdivision at the base of the section, and not near the summit. The other fossils, *Exogyra Texana* (*flabellata*), *Pholadomya Sancti-Sabœ*, *Lima Wacoensis*, *Arcopagia Texana*, *Triginonia crenulata*, *Avellana Texana*, *Cerithium Bosquense*, *Holectypus planatus*, indicate forms of the upper green sand of England, and are found, I suppose, near the summit of Shovel Mountain.

Dr. Shumard gives no reason, stratigraphical or paleontological, for putting the *Caprina limestone* and the *Comanche Peak group* at the summit of the series of cretaceous rocks of Texas, except that he says, the *Caprina limestone* always caps the highest elevations of the table-lands of Texas. This greater elevation does not make it, as a matter of course, a more recent formation, and the contrary is often the case all over the world. Roemer, who considers the cretaceous strata of Texas table-lands as an equivalent of the Upper Chalk of Europe, admits that the strata of the plateaux are *older* than those of the Texas plains, such as the *Austin limestone*.

From the imperfect section of Shovel Mountain, and the list of fossils given by Dr. Shumard of *Comanche Peak group*, I consider that group as of the age of the Green sand, and to be placed below the *Austin limestone*, and the cretaceous rocks of New Jersey; and more, I think it is not rigorously limited, including in the middle and at the base strata, which are probably equivalents of what Dr. Shumard calls *Indurated blue marl*, and the upper portion or even perhaps the whole of his *Washita limestone*.

The *Austin limestone* contains fossils such as *Gryphœa vesicularis*, *Radiolites Austinensis*, *Nautilus DeKayi?*, *Baculites anceps*, *Hemiaster perastatus*, *Corax heterodon*, *Lamna Texana*, which indicate a fauna of the chalk group as well in Europe as America. I regard that subdivision of Dr. Shumard as the youngest of all the cretaceous strata of Texas as yet described; and of the age of the white chalk or *Sénonien* of France.

The *indurated blue marl* or *Exogyra arietina marl*, which comes next in Dr. Shumard's theoretical section, contains the *Exogyra arietina* in profusion, and also the *Gryphœa Pitcheri*. The author says "that it is well exposed towards the base of Mount Bonnell, near Austin." Mount Bonnell is also cited as a typical locality for his *Comanche Peak group;* by giving a section of that mountain, Dr. Shumard would have shown the *Austin limestone* placed according to his views, but none is given. Dr. George G. Shumard found this *indurated blue marl* resting upon the *Washita limestone* in the State of Arkansas, and as the *Washita limestone* is another of the subdivisions not defined with sufficient exactness to serve as a term of comparison, I am inclined to consider the *indurated blue marl* as a subdivision in the middle of the *Comanche Peak group*, and above or even included perhaps in what Dr. Shumard terms the *Washita limestone.*

The *Washita limestone* constitutes according to the author, an important member of the Texan cretaceous system; its name is taken from Fort Washita, where Dr. George G. Shumard found it finely developed. The first *desiderata* are, a good description, bed by bed, of all the cretaceous strata of Fort Washita, with the distribution of the fossils contained in them. This want is not supplied by the memoir of Dr. Shumard; the fossils are given in bulk, although it is more than probable that in those 120 feet thickness of strata, there is a regularity and order in the distribution and relative position of the fossils; they cannot all range from the bottom to the top. It is clear, from the list of fossils, that the greater part of the *Washita limestone* belongs to the lower cretaceous rocks of America, and is on a parallel with the *Néocomien* of the Jura. Without a good drawing of the *Inoceramus problematicus*, and even without a description of the fossil, so called by Dr. Shumard, I may be permitted to doubt its existence; and, if it is found at Fort Washita, it must be in the upper part of the strata, and not in the same bed with *Gryphœa Pitcheri.*

The *blue marl* with *Inoceramus problematicus* was examined by Dr. G. G. Shumard, in Grayson County, and it is given in the theoretical section without saying what strata overlie or underlie it. From the presence of the *Inoc. problematicus* in it, and of fish scales and teeth,

I regard it as younger than the *Washita limestone* and place it below the *Austin limestone*.

The *Caprotina limestone* is the lowest member of the cretaceous strata of Texas. I have seen it on the False Washita, near the Canadian, resting unconformably on the Trias, and passing by almost insensible gradations to the *Gryphœa Pitcheri limestone*. The list of fossils given by Dr. Shumard indicates a Néocomien fauna. As Dr. Shumard cites the foot of Mount Bonnell as one of the typical localities for the *Caprotina limestone*, it is to be regretted, once more, that he did not give an exact real section of that mountain.

Without giving a single locality where the *Caprotina limestone* may be seen clearly and unquestionably overlying the *Arenaceous group*, Dr. Shumard makes a great division which he calls *Lower Cretaceous*, and which, according to his brother, contains, in its upper part, *Ostrea congesta*, *Ptychodus mammilaris*, *Lamna compressa*, *Lamna Texana*, and *Galeocerdo cristodontus*. I found the *Ostrea congesta* at Galistéo (New Mexico), in company with *Inoceceramus problematicus*, *Ptychodus Whipplei*, and a large Ammonite, and I have referred those strata to the Chalk group of Europe. From the fossil fishes determined by Dr. Leidy, I consider the *Arenaceous group* of Dr. Shumard younger than the *Washita and Comanche Peak group*, and of the same age with the fish-bed at the base of the *Austin limestone* and the *Blue marl* of Grayson County. The *Lamna Texana* is, according to Dr. Shumard himself, common to the *Arenaceous group* and the fish-bed of the *Austin limestone;* and the *Ptychodus mammilaris* is a very characteristic fossil of the chalk of France, England, Belgium, Italy, and Germany; so I see no reason, paleontologic or stratigraphic, for placing that division in the Lower Cretaceous rocks.

Marly clay or Red River group. This group is an interesting addition to our knowledge of Texan cretaceous rocks. From its position below the *Arenaceous group*, and from the fauna contained in it, such as *Ammonites*, *Ancyloceras*, *Scaphites*, *Baculites*, &c., all new species related to the Marly Chalk species of Europe or America, I regard it as a part of the Upper Cretaceous, below the *Austin limestone* and the *blue marl with Inoc. problematicus*, but above the *Caprina limestone*. I think it fills up the gap between the deposit of the cretaceous strata of the table-lands and those of the plains of Texas.

Now, if I arrange, in a tabular form, the groups of Dr. Shumard, as I am led to consider them, we shall have the following table: —

Upper Cretaceous or Sénonien.	Austin Limestone.	
	Fish-bed in sandstone (*L. Texana*).	Arenaceous group with *Ostrea congesta*.
	Blue Marl with *Inoceramus problematicus*.	Fish-bed, *Lamna Texana*, &c.
Middle Cretaceous or Green Sand and Turonian.	Marly clay, or Red River group. Caprina limestone. Comanche Peak group (superior part with *Exogyra Texana*). *Exogyra arietina* Marl.	
Lower Cretaceous or Aptien and Néocomien.	Washita limestone (comprising the inferior part of the Comanche Peak group, with *Gryphœa Pitcheri*). Caprotina limestone.	
	Trias or Carboniferous.	

Dr. Benjamin Shumard in this memoir not only synchronizes all the strata of my real section of Pyramid Mount, near the Llano Estacado, with his theoretical section of Texas, and that with such a degree of certainty that he thinks it "scarcely admits of a doubt," but he also regards my *Gryphœa Tucumcarii* as identical with his *Gryphœa Pitcheri*, and my *Ostrea Marshii* with his *O. subovata* of Fort Washita. I have the greatest respect for the labors of Dr. B. Shumard, who is one of the pioneers of the geology of the Mississippi valley, and I do not doubt that he candidly believes he has given a right interpretation to my observations at Pyramid Mount. But however great may be the weight due to the opinion of such an eminent observer, especially when it concurs with that of all other explorers, collectors, and Messrs. Meek, Hall, and Newberry, I continue to believe, very candidly also, that there is not a single stratum nor a single fossil of Cretaceous age at Pyramid Mount. Dr. Shumard thinks that a closer observation than mine at Pyramid Mount, would result in the discovery of the cretaceous fossils of Grayson County, and that my *Ostrea Marshii* and *G. Tucumcarii*, identical or not with his *O. subovata* and *G. Pitcheri*, "hold a position more than two hundred feet above strata that contain well-marked cretaceous types." I can only express the wish that when Dr. Shumard goes to Pyramid Mount, he may find more fossils than I did, and if any of them are cretaceous, and *below* the *Gryphœa Tucumcarii* bed, I am ready to yield to such a proof.

The *Gryphœa Tucumcarii* is a Jurassic fossil closely allied to *G.*

dilatata, *G. cymbium*, and *G. calceolata* of Europe, which have nothing whatever in common with the *Gryphœa Pitcheri* or any other cretaceous species; a clearer Paleontological case can seldom be seen; but Messrs. James Hall, W. P. Blake, and J. M. Meek have contrived to make the matter difficult and dark, in the *Reports on the Pacific Railroad and the Mexican Boundary Commission.* I have always considered their determination of fossils as valueless, and a few words of explanation will show the degree of confidence that is to be placed in them as accurate and reliable authorities.

In vol. III. *of the Pacific Railroad Explorations*, Mr. James Hall has described and figured both fossils as varieties, the one of the other. The descriptions and figures of Mr. Hall certainly do not indicate a single species with varieties, but two distinct species, as broadly distinct as two species of the same genus can be; besides, he refers all the specimens of Pyramid Mount to what he calls the typical form of a *small individual* of Dr. Morton's *Gryphœa Pitcheri*, while his *G. Pitcheri*, var. *navia*, are all from the False Washita, both varieties not being found in the same locality, but at two hundred miles distance from each other. This simple fact of stratigraphical position and distribution is a strong objection to the identification of the two fossils. Plate I., fig. 1–6, represents the *Gryphœa Pitcheri* of Hall (not Morton or Roemer). Compared with the text the figures do not give half the characters, and all the principal ones are wanting; such as being "distinctly lobed," "beak strongly incurved," "umbo large and prominent," "postero-ventral margin sinuate and elevated in a line corresponding to the depression in the opposite valve," "impressed radiating lines near the centre;" in fact, I do not recognize a single one of the figures, drawn by Mr. Meek, as representing any specimens picked up by me at Pyramid Mount, and if any of them came from there they are rolled and worn-out specimens, probably picked up on the banks of Tucumcari Creek by some other members of our expedition. Figures 7, 8, 9, and 10, on the same plate, are intended to represent the *Gryphœa Pitcheri*, var. *navia.* Mr. Hall says in the description, "upper valve unknown," when figure 8 gives a complete specimen with upper and lower valves; figure 9, is also an upper valve of another specimen well preserved. So the text is in complete disagreement with the figures. Further, those figures 7, 8, 9, and 10, have been copied from my plate published in May, 1855, in the *Bulletin de la Soc. Géol. de France*, vol. XII. pl. XXI., and the copy was so carelessly made by Messrs. Hall, Blake, and Meek, that they have put the figure 10 as the side view of the upper valve of figure 9, when in fact it is the side view of the upper valve of *Gryphœa Tucumcarii*, figured under the number 1 *a* and 1 *b* on my plate, a specimen which has nothing to do whatever with the False Washita specimens, even taking for granted the opinion of

Mr. Hall, that it is *G. Pitcheri*, var. *navia*. These examples will suffice to show the accuracy of the *Paleontology* of vol. III. of the *Pacific Railroad Exploration*.

We will now pass to the first volume of the *United States and Mexican Boundary Survey*. In the chapter by T. A. Conrad, *Descriptions of Cretaceous and Tertiary Fossils*, page 141, this learned paleontologist describes, at page 155, the *Gryphæa Pitcheri*, plate VII., figure 3, and plate X, figure 2. In the synonymy, he gives *Gryphæa Pitcheri*, Morton, which is right, for it is the species which he figures under the number 3 *a*, 3 *b*, representing, as Morton does, a young individual of the species.* Conrad gives also as synonym my *Gryphæa dilatata* var. *Tucumcarii* such as is represented in figure 3, or elongated variety, in the *Bulletin de la Soc. Géol. de France*. This is a mistake, and he corrects it in a letter, which I will give a few lines further on. I agree entirely with Mr. Conrad, in his description of specimens figured. Plate VII., figure 3 *a*, 3 *b*, represents a young individual, and figure 3 *c*, 3 *d*, is a full-grown but broken specimen, representing the common form of the *Gryphæa Pitcheri;* figures 3 *g* and 3 *f*, represents the smaller valve of the *Gryphæa Pitcheri*. Plate X, figure 2 *a*, 2 *b*, represents an upper valve of the *Gryphæa Tucumcarii*, so far as I can judge of the drawings without a description, for there is none given.

It seems needless to make a var. *navia* for the young individual, merely to express a difference in age.

Mr. Dana, in his *Review of Marcou's Geology of North America*, having quoted Conrad's opinion against me, I was led to inquire more closely into the matter, as I have a great respect for that Paleontologist, and wished to discover, if possible, the reasons why such an observer should hold so different an opinion of those two *Gryphææ* from that of Deshayes, D'Orbigny, Agassiz, Pictet, and D'Archiac.

* I have never seen Morton's original specimen. If the figure in his *Synopsis of the Cretaceous Group of the United States*, plate XV., figure 9, is correct, it differs in its general outline and in the details of both valves, from the young specimen of *G. Tucumcarii*, published in my *Geology of North America*, plate IV., fig. 2; and as it differs even more from the young specimen of *G. Pitcheri*, figure 6, on the same plate, I am led to believe that I did not meet with the true *G. Pitcheri* of Morton, in my explorations with Captain Whipple's party. Mr. Ferdinand Roemer having the opportunity of seeing in the company of the late Dr. Morton himself, the original specimen at Philadelphia, I naturally followed his identification of *G. Pitcheri;* and if Roemer has made a mistake, I was misled by his description in *Die Kreidebildungen von Texas*. Thus we shall have three species of *Gryphæa;* 1, the *G. Tucumcarii* of the Jurassic rocks of Pyramid Mount (New Mexico); 2, the false *G. Pitcheri*, of Roemer and Marcou, or the false *G. Pitcheri* var. *navia* of Conrad and Hall, of the cretaceous rocks of the false Washita River (Texas), which may be called *G. Roemeri*, in honor of its first discoverer, Mr. F. Roemer; and 3, the true *G. Pitcheri* Morton, which I have never seen, and, consequently, on which I cannot give any information as to its stratigraphical position and association with other fossils.

On looking more closely at the plates of the *Mexican Boundary Report*, I found on the last plate, No. XXI., figure 3 *a*, 3 *b*, 3 *c*, a specimen of *Gryphœa Tucumcarii* under the false name of *Gryphœa Pitcheri.* Mr. Conrad, in his description of *Gryphœa Pitcheri*, p. 155, makes no reference whatever to that plate, nor to the figures 3 *a*, 3 *b*, 3 *c;* and in the *Explanation of Plates of Prof. Hall's Report*, p. 174, nothing is said of the locality or the stratigraphical position of this fossil. The plate was drawn by Mr. F. B. Meek, who has put it under the head of *Cretaceous.* The mysterious appearance of this beautiful fossil is rendered still more suspicious from the fact that, at p. 144, reference is made to plate XXI., in order to bring in the supposed *Gryphœa Pitcheri*, figured upon it, as a proof of the cretaceous age of the formation; and Mr. Agassiz is made (in a foot-note) to sustain this opinion, although it is well known that he has considered these two fossils as distinct, from the beginning.

For any reader not deeply interested in the matter, that page 144 of the *Description of Cretaceous and Tertiary fossils* by Conrad, will seem to be written by Conrad himself; when in fact Mr. Conrad had nothing to do with it, and in order to find the writer we must look at the foot of page 103 of *Geology and Paleontology*, by Mr. J. Hall, where, in a foot-note, he says that he has described the "Echinodermata at the request of Mr. Conrad, putting them in their proper place," without saying if it is also at the request of Mr. Conrad that, in describing his Echinodermata, he figured in plate XXI. a *Gryphœa Tucumcarii* under the false name of *G. Pitcheri.* Desirous to know the opinion of Mr. Conrad himself on these incomprehensible and doubtful proceedings, I wrote to him, and give below his answer:—

PHILADELPHIA, *January* 25, 1861.

JULES MARCOU, ESQ.:

Dear Sir: — . . . . . When I drew up the Report in Emory's Survey, I was shown by Professor Hall a series of *Gryphœa*, some of which were undoubtedly your *G. Tucumcarii*, as figured on plate XXI. Professor Hall thought they graduated into *G. Pitcheri*, and I thought so at the time. The name of your species ought not to have been placed as a synonym to plate VII., figure 3, for it is undoubtedly *G. Pitcheri.*

But the figures on plate XXI. represents a species and specimen, the locality of which is *unknown* to me, and were engraved *after* I had sent in my report and descriptions. So that I can now say, that I do not know whether *G. Pitcheri* is identical with your species or not.

The localities of the *G. Pitcheri* (page 155, Lèon Spring, Texas; plains of Kiamesha, Arkansas; New Braunfels, Texas; Fort Washita and Cross Timbers, Texas), are correctly given, from MSS. accompanying the specimens.

. . . . . sincerely yours, T. A. CONRAD.

That the *G. Tucumcarii* is found at Lèon Spring, is a fact first made known in my Report of 1854, from a specimen picked up there by Dr. Kennerly, and it is also certain that cretaceous fossils have

also been found there by Col. Emory; but it is not necessary to place the *G. Tucumcarii* in the same bed with the cretaceous fossils, for the Jurassic and cretaceous rocks may well exist together in that locality. I have always believed that the cretaceous strata would be found *overlying* the Jurassic rocks on the plateau between Rio Pecos and the Rio Grande, on the road to El Paso, and I have no doubt that a practical geologist will one day give a detailed section, showing such an arrangement of the strata in the vicinity of Lèon Spring.

I have taken pains to have a very good plate of the *G. Tucumcarii*, *G. Pitcheri*, and *O. Marshii*, drawn in Paris by the best artist there for fossils, M. Humbert; that plate is not only in the *Bulletin de la Soc. Géol. de France*, vol. XII., but also in my *Geology of North America*, with descriptions of the three species. I have placed specimens in a good state of preservation in the following collections: Museum des Naturalistes de Moscow; Museum at Berlin by Humboldt himself and Mr. Mulhausen; at the Museum of the Universities of Munich, Basle; at the Royal Museum at Stuttgart; at the École Polytechnique of Zurich; at Pictet's collection at Geneva; D'Archiac's collection; at the Jardin des Plantes, and the École des Mines, at Paris; at the Geological Society of London (where are the specimens figured on the plate); and finally, at the Museum of Comparative Zoölogy of Mr. Agassiz, at Cambridge, Mass. So it will be always easy to see what I mean by *G. Tucumcarii* and *G. Pitcheri*, notwithstanding the Hall, Blake, and Meek imbroglio.

In conclusion, if Dr. B. Shumard continues to hold the opinion that he finds my *G. Tucumcarii* and *Ostrea Marshii* at Fort Washita, with cretaceous fossils, I hope he will be induced to give a good drawing of them, with detailed descriptions, and a real section of the strata at Fort Washita, like my detailed section of Pyramid Mount, in order to allow geologists to judge for themselves *avec connaissance de cause;* but as long as he contents himself with simple affirmation, and theoretical sections, his views will have no more weight than a mere contradiction of mine, without proofs to sustain them.

A Card. — The late proceedings of Messrs. James D. Dana and Benjamin Silliman, Jr. towards me have been of such a nature, that I regret extremely having taken any notice of the numerous attacks made, sometimes by themselves, and sometimes by others with their sanction, as Editors of the *Journal of Science and Arts*. Had I been sooner aware of their true character as the only responsible Editors of an unscrupulous scientific periodical, which has become notorious for its plagiarism, bad taste, partiality, and false statement of plain facts, I should have remained silent, and will do so in future, whatever charges they may bring against me in their so-called *Journal of Science*.

JULES MARCOU.

Cambridge, *May*, 1862.

LETTER

TO

M. JOACHIM BARRANDE,

ON THE

TACONIC ROCKS OF VERMONT AND CANADA.

CAMBRIDGE, MASSACHUSETTS, *August* 2, 1862.

MY DEAR M. BARRANDE:—

Having just returned from a third exploration of the vicinity of Quebec, and a second visit to Georgia, I shall send you in a few days by express two boxes, containing all the Taconic fossils that I have been able to collect during the two last years, and which form a part of the paleontological collection of the Museum of Comparative Zoölogy at Cambridge.

You may keep for yourself a specimen of each species when there are duplicates, and when you have studied them, please return the collection, labelled by you, with your remarks and descriptions of new species; it will be carefully preserved here, as the most precious collection for reference and comparison in the future study of the Taconic System of North America. I will put in the boxes all the specimens of *Paradoxides* and other Trilobites found by me at Braintree; also the best specimen of *P. Harlani* ever found there; it belongs to my honored friend, Dr. C. T. Jackson, who very kindly consents to send, not only that specimen for your inspection, but all others in his possession relating to the Taconic, including a specimen of *P. Bennettii* of Newfoundand, and a cast of the same from a more complete specimen. Dr. G. M. Hall, and Rev. J. B. Perry of Swanton, sent me last winter a valuable collection of primordial fossils from that vicinity, and, lastly, Colonel E. Jewett of Albany contributes a rare collection of fossils from some lenticular masses of limestone enclosed in the Taconic slates

near Troy (New York). I should have been delighted to send you some specimens from the author of the *Taconic System*, Dr. Emmons, but I have not heard from him since February, 1861; he resides at Raleigh in North Carolina, and no communication is allowed or possible with him at present.

The Geological Survey of Canada possesses a large collection of Taconic fossils, and I tried to obtain for you, and in your name, a single specimen of a pygidium of *Dikelocephalus magnificus*, not having been successful in my search for it at Point Lévis, although I found a large number of the glabellæ; but I received so neat a refusal, that I did not dare to ask anything else. I have already told you that we must not expect any aid, material or intellectual, from that quarter.

I shall now be able to finish promptly the memoir with geological maps and sections which I have had in preparation since last year, and I trust it will reach you before the first meeting of the Geological Society in November next; so that, as you will have the fossils previously, you will be able, on presenting my memoir for publication in the *Bulletin de la Société Géologique de France*, to give at the same time your views and remarks upon the paleontology of the Taconic rocks. In order to enable you to understand the stratigraphical order, I send you now a very short *Résumé*, with two theoretical sections, containing the corrections and important additions which I have made since the publication, in November, 1861, of my first *Résumé*, entitled *The Taconic and Lower Silurian Rocks of Vermont and Canada.* (Proceed. of the Boston Soc. of Nat. Hist.)

EXPLANATION OF FIG. I. — *Abstract section for the vicinity of Georgia, St. Albans, Swanton, and Philipsburg.* I have comprised Philipsburg (Canada East) in the same section with Swanton and Georgia, because the physical geology of these different places is so connected and similar that it is impossible to describe the northwest corner of Vermont without referring to Philipsburg, St. Armand, and Frelighsburg; and, on the other hand, Canada East cannot well be understood without reference to the discoveries made in Vermont.

St. Albans Group. — The granular quartz and quartzite found in semi-stratified lenticular masses at the base of the St. Albans group ought to be included in it, so that the Lower Taconic begins with the Talcose slates so well developed east of St. Albans on the

Fairfield road. This may increase the thickness of the St. Albans group one thousand or fifteen hundred feet, but I will retain the number of 3,000 feet as the minimum thickness of the group. The lower part, with quartz veins and quartz masses, may be well observed near the Georgia railroad station. *The Roofing Slates* are above, and can be seen on the line of railroad between St. Albans and Georgia.

Another fragment of a Trilobite, similar to the one found east of St. Albans, and related to the genus *Olenus*, but not well enough preserved for determination, has been found in this group near Franklin, by Mr. Perry. But the most important discovery in this group was made by Dr. Hall, who found, in one of the lenticular masses of hard blue limestone at Highgate Falls, the pygidium of a small *Bathyurus*, different from any one yet described. We must look for further discoveries in that lenticular mass of limestone at Highgate Falls.

Georgia Slates. — I have studied with the greatest pleasure, under the guidance of Messrs. Perry and Hall, the new locality of *Olenellus Thompsoni* Hall, *Ol. Vermontana* Hall, *Conocephalites Teucer* Bil., *Obolella cingulata* Bil., *Orthisina festinata* Bil., and *Camerella antiquata* Bil., found by them, shortly after my visit last year, a mile and a half east of the village of Swanton, on a farm belonging to Dr. Hall, and which I will call *Dr. Hall's farm.* The rocks are the same as on the farm of Mr. Parker, at West Georgia, and the fossils, though not abundant, are found in fragments. I observed here a new feature in this group, which led me to remove higher up in the series the lenticular mass of the Redoute at Point Lévis. Two lenticular masses, separated by fifty feet of slates and sandstones, and composed of very hard blue, gray, and white limestone, are found on Dr. Hall's farm, near the middle and upper part of the group. Fossils are common in them, and I collected quite a number of *Obolella cingulata*, *Orthisina festinata*, *Conocephalites Teucer?*, and a *Lingula;* and I am almost certain that *Olenellus Thompsoni* and *O. Vermontana* will be found there, just as they were found in a white limestone on the Labrador coast last year, by Mr. Richardson. These two masses, which I call *Lenticular primordials*, because they contain only primordial fossils, are not large, one being 40 feet in diameter, and the other less wide, but more elongated. The last year's estimate of 500 to 600 feet for the thickness was too high, and I now reduce it to 400, as being nearer the truth for the Georgia group.

Philipsburg Group. — The Georgia slates are followed in regular order by at least 1,400 feet of light black slates, containing, now and then, large lenticular masses of limestone, often called in Vermont *Dove Marble* or *Eolian Limestone* of Hitchcock. In some places, as at St. Albans Bay, Smith Kiln, and Swanton, the lenticular masses are isolated, and form small domes or isolated hills in the middle of the slates; while at Highgate and Philipsburg, the slates, on the contrary, are almost lost in the middle of numerous very large lenticular masses of limestone closely packed together, with only a sort of network of slates enclosing them, and forming, as it were, a frame or border.

From the mouth of Rock Creek near Highgate Spring, as far as Bedford, that is, for a distance of ten miles, and two miles in width, from the lake shore to Four Corners on Moore's Corner, we have an accumulation of lenticular masses originating most probably from mineral springs charged with abundance of carbonate of lime, carbonate of magnesia, and oxide of iron. This locality presents a most interesting study to the geologist and zoölogist, and is, perhaps, with Point Lévis on this continent, and Bruska, Gross-Kuchel, near Prague, in Bohemia, one of the few favored spots for the study of that vexed question, so often talked of, yet so little understood, *the origin of species.* Yes, my dear M. Barrande, we have here at Philipsburg that curious phenomenon which you were the first to discover in Bohemia sixteen years ago, and which you are at present engaged in defending against the attacks of the official geologists of the Austrian Geological Survey. We have what you will call *Colonies of the Second Fauna* enclosed in the strata containing the *Primordial Fauna;* and what I propose to call *Precursory Centres of Creation;* that is to say, centres in which the Creator has made to appear *forerunners* (*avant-coureurs*), species, or generic types, which obtain their full development only during the following great period. Hitherto the study of these lenticular masses near the boundary-line of Canada and the United States has been limited to the immediate vicinity of Philipsburg and Four Corners; future researches will no doubt disclose other localities both in Canada and Vermont. For the present, I have tried to give on the *abstract section* the part of the country between Philipsburg and Four Corners, in following the road to Frelighsburg or exploring the different paths which lead to Eaton's barn and Blanchard's farm. At Four Corners the

bluffs of limestone overlooking the houses contain a quantity of Gasteropoda, mostly *Murchisonia Hyale* Bil., *Metoptoma Eubule* Bil., and *Maclurea;* they are enclosed in a hard limestone and very difficult to obtain, but are very abundant and easily seen on the polished surface of the limestone. Ascending the series, we come to other lenticular masses near Blanchard's farm containing *Maclurea*, *Ecculiomphalus*, and *Orthis;* then on reaching the main middle ridge about half-way between Four Corners and Philipsburg, we meet first on the surface of the bluish-gray limestone well-preserved sections of large *Lituites* and *Orthoceratites*. The *Lituites Imperator* Bil., and *L. Farnsworthii* Bil., are quite common here, but can only be obtained by the laborious process of the stone-cutter. A peculiarity in the rocks, which break in a sort of slaty way, is, that you cannot see the *Lituites* in the limestone, but only on the polished surface. Fifty feet farther west we meet a layer of hard gray limestone, eight or ten inches thick, passing into a magnesian limestone charged with a quantity of oxide of iron, which is easily decomposed by atmospheric agency. This layer, which is only known for a space of one hundred to one hundred and fifty feet, is very remarkable, because it contains an immense quantity of fossils; in fact, it is a true lumachella of *Bathyurus Saffordi* Bil., *Amphyon Salteri* Bil., two new species of *Dikelocephalus*, one *Asaphus*, *Nautilus Pomponius* Bil., *Cyrtoceras*, *Orthoceras*, *Metoptoma Niobe* Bil., *M. Orithyia* Bil., *Holopea Proserpina* Bil., *Murchisonia Vesta* Bil., *Pleurotomaria Portunica* Bil., *Ecculiomphalus Canadensis* Bil., *E. intortus* Bil., *E. spiralis* Bil., *Ophileta complanata* Van., *Maclurea matutina* Hall, *Orthis Hyppolyte* Bil., *Camerella calcifera* Bil., crinoides, and one or two very rare corals. Farther west, near Eaton's barn, the *Camerella calcifera* is quite abundant. Indistinct fossil shells have been indicated on other points near the village of Philipsburg, but no other rich localities for fossils have been found in the Philipsburg group except those indicated above. Several species, such as *Camerella calcifera*, *Murchisonia Vesta*, *Maclurea matutina*, and *Ophileta complanata*, seem to appear in every lenticular mass, and to range all over the Philipsburg group; while others, such as *Bathyurus Saffordi*, *Amphion Salteri*, *Dikelocephalus*, *Asaphus*, are not only confined to a single one of the lenticular masses, but are even there found in a sort of nest, or more probably a true centre of creation. Mr. Billings has already described or identified about

twenty species from the vicinity of Philipsburg, and from twenty to thirty remain undescribed, so that we may assume fifty species as the number of fossils already found in the different lenticular masses of Philipsburg. Of these, — two *Dikelocephali* and one *Menocephalus* belong to the primordial fauna; the two *Bathyuri* may be considered as belonging to a genus which is common to the first and second fauna, and all the other fossils belong to the second fauna; several, such as *Camerella calcifera*, *Maclurea matutina*, *Ophileta complanata*, and *Ecculiomphalus intortus*, pass into the lower part of the Champlain formation or Calciferous sandrock. Thus we have here lenticular masses of limestone enclosed in the Upper Taconic, and containing precursory or forerunning species and genera of the second fauna. These rocks dip to the east at an average angle of about 25°, varying from 15° to 35°. There are no faults, no foldings, no repetitions of strata; and the Philipsburg group of rocks, instead of belonging to the upper part of the Calciferous sandrock, and even to the Chazy limestone, which it has been referred to by Mr. Billings in his memoir entitled, "*On some of the Rocks and Fossils occurring near Philipsburg, C. E.*" (see *Canadian Geologist*, August, 1861, p. 310), is far below the Potsdam sandstone, and in the middle of the Upper Taconic.

Last year my observations in Vermont were more especially directed toward the St. Albans group, the Georgia slates, and the Red sandrock, or Potsdam sandstone, which were then called by Messrs. Logan, Hall, Rogers, and others, Hudson River group, Oneida conglomerate, Medina sandstone, and metamorphic Devonian; and, as I remained only a few hours at Philipsburg, I adopted without examination the opinions expressed by Mr. Billings, in his memoir above quoted; but a careful survey this year has convinced me that at Philipsburg, as well as at Point Lévis, Mr. Billings has been misled in giving explanations, and arriving at conclusions, in his paleontological researches, which are entirely at variance with what exists in nature, — an error that would not have occurred if the paleontologist of the Canada Survey, who does not pretend to be a stratigraphical observer, had been better seconded by the other members of the Survey.

Swanton Slates. — The Swanton slates, so well developed all round the village of Swanton, are composed of black slates, interstratified, now and then, with thin layers of a marly limestone from

two to six inches in thickness. The color varies, and in some places they become brownish and gray. Their thickness cannot be less than two thousand feet. Mr. Perry has found two *Graptolites* in them on the shore of the lake at Philipsburg; and Dr. Hall gave me specimens of *Graptolites pristis* His, collected by him at the fall of the river in the middle of the village of Swanton, where they are quite numerous. This discovery is important, because, as we have also the *G. pristis* from the Utica slates, it proves that species to be a precursor common to the primordial and the second faunæ; consequently it is insufficient alone to determine the horizon of a system of rocks. Until now, no lenticular masses of limestone have been found in the Swanton slates of Vermont; but I am inclined to believe that there are such masses in the State of New York. For instance, at Troy, near Albany, there are lenticular masses of blue limestone enclosed in the Swanton slates, and which contain sporadic types or precursory species of the second fauna, as you will see from the collection made in one of them by Colonel Jewett.

Potsdam Sandstone. — I have little to add to what I said last year of this group. As I told you, being the capping group in the overturn of the Taconic system, where it found a point of resistance, such as all along the *terra firma* of the Adirondack Mountains, it broke into narrow, parallel bands, which have rested *en échelons* upon the different groups of the Upper Taconic. The Potsdam sandstone enters Canada, and crosses the Frelighsburg road at Krantz's mill, but does not appear north of Missisquoi County.

As regards what I called last year the Utica slate of Highgate Springs, I am inclined now to think that those slates do not belong to the Utica slate, but are included in the Chazy and Black River formation. I should say the same of a part of what I then called *Lingula flags* at Highgate Springs. Since my visit of last year, Dr. Hall has found in them *Ampyx Halli* Bil.; and, from their association at Highgate and St. Albans Bay, I think, with Dr. Hall, that they belong also to the Chazy and Black River formation, — that is, instead of being contemporaneous with the *Lingula flags* of England, they are of the age of the *Llandeilo flags*.

EXPLANATION OF FIG. II. — *Abstract Section for the vicinity of Point Lévis, Chaudière, and Quebec.*

Chaudière and Sillery Group. — The inferior part of the Upper Taconic in the District of Quebec is formed of red shales, some-

times brown, olive, or even black, passing now and then into beds of red sandstone one or two feet thick, and which is entirely cut up and crossed in all directions by dikes of trap greenstone, containing sometimes crystals of feldspath, and being then a true porphyry.

There are numerous instances of a sort of semi-stratification in this trap; but generally they are in dome-shaped dikes or masses. Only one fossil has been found, as yet, in the slates near Chaudière Falls by Mr. Richardson; it is a small *Obolella*, described by Mr. Billings under the name of *O. pretiosa.* The thickness of the whole group is at least three thousand feet. It corresponds entirely to the St. Albans group of Vermont, the trap replacing the injection of granular quartz.

Redoute and Gilmour Group. — At Gilmour's Wharf, and on the road to Arlaka, near the Redoute or Lime-kiln (*four à chaux*) of Point Lévis, there are about four hundred feet of green and black slates, containing layers of magnesian conglomerates, yellow sandstones, and finally a large, lenticular mass of very hard, white limestone, which I called last year the *Redoute*, or quarries of the Notary Guay. The fossils found at the Redoute are all primordial, and many of them new, as you will see in my collection; and I consider it as a *lenticular primordial*, of almost the same age, or very little younger than the two lenticular primordials of Dr. Hall's farm in the Georgia slates of Swanton. Then, instead of placing the slates, limestones, and magnesian conglomerates of Gilmour's Wharf and the Redoute in the St. Albans group, as I did last year, I am led to remove them a little higher up in the series, considering now that group as the equivalent of, and contemporaneous with, the Georgia slates of Vermont. The principal fossils found at the Redoute are, *Dikelocephalus magnificus* Bil., *D. planifrons* Bil., *D. megalops* Bil., *Conocephalites Zenkeri* Bil., *Bathyurus capax* Bil., *Monocephalus Sedgewicki* Bil., &c.

Point Lévis Group. — With the help of two good maps, the *Plan of the Harbor of Quebec*, by A. Wallace, 1861, and the *Plan de la Ville d'Aubigny dans la Seigneurie de Lauzon*, department of Crown Lands, 1862, I was able this year to follow out and trace every bed and layer, on the whole contour of Point Lévis, from the Grand Trunk Railroad Terminus to Indian Cove; and as Point Lévis is a point of land surrounded by high cliffs, I feel satisfied that there is no repetition of beds, and no synclinal axis, and that the few foldings in the strata of the Ferry's Cliff are mere acci-

dents, confined to a distance of a few feet, and are without any effect upon the whole mass of strata, but are what we call in French *structure ployée* (contorted beds). You will ask, what becomes of the discordance of stratification that I indicated last year, as existing between the Redoute and the *Strata de la terre du Curé*. There is, in truth, here, as well as at Philipsburg and St. Albans, a difference of direction between the masses of slates and the limestones near the contact of the two rocks; but I feel assured now that this difference is due to the globular form of some of the lenticular masses of limestone enclosed in the slates, the slates following the direction of the globular mass, instead of running in a straight line, which gives to the whole, at first view, a sort of discordance of stratification that in truth does not exist.

Between the Redoute and the *Strata de la terre du Curé*, there are about one hundred or one hundred and fifty feet of black slates; then we have three lenticular masses of limestone, separated by about thirty feet of slates interstratified with some beds of magnesian conglomerate and yellow sandstone. These masses are almond-shaped and quite flat, from ten to twenty feet broad, and one hundred to one hundred and fifty feet long, and the limestone, although quite hard, is less so than at the Redoute. In order to understand the localities, I shall call the first almond, that is the most easterly and the nearest to the Redoute, *Parochial Hill*, because it is the only one crossed by the Parochial boundary-line between the parishes of Notre Dame and St. Joseph. The second shall be called *Middle Hill*, while the third, which is the broadest, and close by the houses of the village, shall be called *Cross Hill*, because a conspicuous Temperance Cross has been erected on it.

The limestone of Parochial Hill contains numerous fossils, especially *Bathyurus Saffordi* Bil., *B. Cordai* Bil., *B. bituberculatus* Bil., *B. oblongus* Bil.; *Arionellus*, n. sp.; *Ecculiomphalus Canadensis* Bil., *E. intortus* Bil.; *Pleurotomaria vagrans* Bil.; *T. Postumia* Bil.; *Metoptoma Hyrie* Bil., *M. Augusta* Bil.; *Camerella calcifera* Bil., *Leptæna sordida* Bil., *L. decipiens* Bil.; *Orthis gemmicula* Bil., *O. Tritonia* Bil., *O. Electra* Bil., *O. Hippolyte* Bil., *O. Eudoria* Bil.; *Stricklandia? Arachne* Bil., which indicates a centre of creation or *Lenticular precursors* of species of the second fauna enclosed in the primordial zone, analogous and most certainly contemporaneous with the lenticular precursors of the Philipsburg group.

The limestone of the Middle Hill contains also numerous fossils, some identical with those found at Parochial Hill, such as *Bathyurus Saffordi* and *Camerella calcifera*, and some new species, such as *Cheirurus Apollo*, *Illænus*, *Asaphus*, and several *Orthoceratites* undescribed. The whole indicates a centre of creation, or colony containing precursory species and prophetic types and genera of the second fauna. At Cross Hill I found only *Camerella calcifera*, but probably other species will be found there also.

I have taken the greatest care to ascertain that these three hills are really lenticular masses, and are not a repetition of each other; that they are independent, although belonging to the same subdivision of the Point Lévis group, which I shall continue to call *Strata de la terre du Curé*. We have here, as at Philipsburg, about fifty species, and several of them are identical with those of the latter locality. Two or three of the *Terre du Curé* species are primordial, while all the others belong specifically or generically to the second fauna. When you have received the boxes of fossils, you will be better able than I am to give a correct list of them for each of the different lenticular masses.

The strata of the *Terre du Curé* are about five hundred feet thick. Succeeding them is a group of slates containing numerous layers of marly limestone and conglomerate. In the cliff near the Ferry are found, besides numerous compound *Graptolidæ*, the following fossils: *Obolella desiderata* Bil.; *Lingula Irene* Bil., *L. Quebecensis* Bil., and *Shumardia granulosa* Bil.; an ensemble more nearly related to the primordial than to the second fauna. These rocks have a thickness of about five hundred feet; they form the most northern part of the cliff of Point Lévis opposite Quebec, and are seen with their *Graptolidæ* on the island of Orleans, near the village Montcalm. I shall call them *Strata of the Ferry's Cliff*, and consider them with the *Strata of the Terre du Curé* as forming the *Point Lévis group*, and the whole as contemporaneous with the *Philipsburg group* of Vermont and Missisquoi county.

Quebec Group. — The city and citadel of Quebec, and the plain extending between the city, Beauport, Charlesbourg, and Indian Lorette, is formed by a great group of black slates, sometimes gray and even reddish, containing now and then, but more especially at the base, numerous layers of blue limestone. Boulders of limestone of quite a large size may be seen in the slates, as at Mountain Street, in the interior of Quebec. These rocks are almost destitute

of fossil remains; but Mr. Richardson has found at the Isle of Orleans *Graptolites pristis* His.; the same that has been found at Swanton Falls, which is common also in the Utica slates. I regard the Quebec group as contemporaneous, and representing at Quebec the Swanton slates of Vermont; although they appear to be more developed, having at least a thickness of 2,400 feet.

Potsdam Sandstone.— The Potsdam Sandstone does not exist in the District of Quebec, and I did not see a single trace of it north of the Grand Trunk Railroad from Richmond to Montreal. Probably, if these rocks were ever deposited in that region, not finding any point of resistance close by, as in the Adirondack country, they slipped under all the other strata in the overturn of the Taconic, and have been entirely concealed from view by the succeeding groups.

My first impression, published from my old manuscript notes of 1849, in our memoir *On the Primordial Fauna and the Taconic System,* with regard to the Champlain or Lower Silurian rocks found northwest of Quebec, which form a narrow band running from St. Anne to Montmorency, Beauport, Charlesbourg, and Indian Lorette, is the right one. These rocks have been deposited horizontally upon the very much inclined Upper Taconic strata, as can be seen in several places at Beauport, Charlesbourg, and Petit Ruisseau; the subsequent denudation and upheaval has formed chasms in the soft gray shales of the Quebec group, more especially near their contact with the quartzite, as at Montmorency Falls and Indian Lorette, into which the Lower Silurian strata have slipped and been in this manner, as it were, boxed up and preserved from the following great denudations which have swept away a great part of that formation in the valley of the St. Lawrence.

The section of Montmorency Falls shows a fine example of this slipping of the Silurian rocks, but the denudation caused by the fall has already reached the contact of the Silurian strata with the Taconic slates, and the water at the foot of the fall passes now under the Trenton limestone.

As you may see from what precedes, I consider the second view taken by the Geological Survey of Canada to be as erroneous as the first one, and entirely at variance with the facts as they exist at Quebec. Obliged to reply to the publication of your letter of August 14, 1860, and my additional notes upon the vicinity of Quebec, Mr. Logan endeavored to throw all the blame upon the

paleontological views of Mr. James Hall; and in his incomprehensible letter to you, written December 31, 1860, ten days after his reception of our memoir, to which he carefully avoids any allusion, in order to shield the blunder of Hudson River group and metamorphic Upper Silurian and Devonian, he has recourse to a break with an overlap, complicated with fault, synclinal and anticlinal axis, unintelligible lettered outcrops or so-called outcrops, diving apparatus to explore the bottom of the St. Lawrence, — in fact, he calls to his aid all the most complicated phenomena of disturbance preserved in the arsenal of dynamic geology, candidly believing that an official geologist may reconcile incorrect observations and false theories by using big words and technical expressions.

I should not have recalled the mistakes of Mr. Logan, if that geologist had not published a sort of contradiction of my observations, in a little memoir, entitled "*Considerations relating to the Quebec Group*," &c., (see *Canadian Geologist*, May, 1861,) in which he gives two most fantastic sections, — calling quartzite, gneiss; a slip, a fault; a regular superposition, an overlap; the Swanton slates, Hudson River shales; sandstone of the Champlain group, Potsdam sandstone, &c. Besides, in a new paleontological memoir just published (June 6, 1862) under his direction as Superintendent of the Geological Survey of Canada, Mr. Billings has taken pains to give new lists of fossils from what he calls limestone No. 1 and No. 3 of Point Lévis, in which he gives names of species common to Nos. 1 and 3, contrary to my conclusions of last year, that *I found no mixture whatever of fossils of the second fauna in the lenticular primordials of the Redoute.*

Mr. Billings says: "I have never visited the locality of the limestones at Point Lévis but once, and that was a few days after the Trilobites were collected. On that occasion I found very few fossils, and made no attempt to study the stratigraphy of the place, which is much complicated." Notwithstanding that declaration, Mr. Billings maintains his imaginary divisions of limestone, Nos. 1, 2, 3, and 4, and proceeds at length, drawing conclusions for the synchronism of the Point Lévis limestones. Fearing that my first unsuccessful attempt last year to understand the explanations of Messrs. Logan and Billings might be my own fault, I tried very hard this year again when at Point Lévis, but with no ~~l~~etter success; and I left Point Lévis fully convinced that the fossils described by Mr. Billings, and the so-called outcrops A_2, A_3, A_4, etc.

of Mr. Logan, were collected and observed in a very careless way, without regard to stratigraphy, by irresponsible collectors, or by unskilful practical geologists.

In passing through Montreal I visited the public Museum of the Geological Survey, and saw the specimens called Limestone Nos. 1, 2, 3, and outcrops A_2, A_3, A_4, etc. After a careful examination of the specimens, and more especially of those cited by Mr. Billings as containing species common to Nos. 1 and 3, I saw that a mixture of specimens had been made, and on closely interrogating a member of the Survey, with a sketch of the contested ground in hand, I finally obtained the answer, that the Redoute was not known as containing fossils *until after* my exploration and publications of last year; that Limestone No. 1, or outcrop A_2, was only a *boulder*, two feet in diameter, found lying on the superficial soil between the Redoute and the *Terre du Curé*, not far from the Lime-kiln. That boulder is very rich in Trilobites, as it is almost a complete mass of them. It came without doubt from the Redoute, and I can almost point out the exact spot from which it came. Every fragment of it has been carefully collected, and the whole is preserved in the Museum, with the exception of a few specimens, which have been distributed in the United States and in England, to more favored geologists than ourselves. But we have not done with boulders; the Limestone No. 3, or outcrop A_3, was also found in *boulders* or *loose pieces* scattered over the *Terre du Curé*, and I do not doubt that No. 3 as well as No. 1 came from the Redoute; which explains very naturally the so-called mixture of species between Nos. 1 and 3. Thus you see the way in which the exploration of Point Lévis was conducted by the official geologists of Canada, and it is not strange that we could not understand their explanations.

I hope this statement will be of some practical use, and that in future more care and application will be bestowed upon the geology of Canada, by those intrusted by the government of that colony with the duty of exploring and reporting upon its geological structure and its mineral wealth.

Very truly, your friend,

JULES MARCOU.

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crystallized and re-arranged the already-formed amorphous silicates. The chemical agencies which gave rise to these silicates of lime, magnesia, iron, and alumina were briefly discussed and declared to be still active, although, probably, to a less degree than formerly.

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3. Section of the Rocks in Eastern Kansas. By G. C. Swallow, of Columbia, Missouri.

SYSTEM I. — QUATERNARY.

Formation *a* — Alluvium.

No. 1. — Soil — Everywhere. 1 to 6 feet.
No. 2. — Sandbars — Missouri and Kansas rivers. 10 to 20 feet.
No. 3. — River bottoms — Sands, clays, pebbles, and vegetable mould or humus — All streams. 20 to 30 feet.

Fomation *b* — Bottom Prairies.

No. 4. — Sands, clays, and marls — Large streams. 25 to 30 feet.

Formation *c* — Bluff.

No. 5. — Silicious marls and sands — On all the highlands under the the soil. 1 to 150 feet.

Formation *d* — Drift.

No. 6. — Sands, pebbles, and boulders — Generally distributed under the strata above-named, and resting upon the consolidated strata below. 1 to 20 feet.

SYSTEM II. — TERTIARY.

In Western Kansas, but not yet observed in Eastern Kansas.

SYSTEM III. — CRETACEOUS.

But partially developed in Central Kansas.

No. 1. — Brown ferruginous, yellow and buff sandstone —Generally classed as cretaceous, but saw no positive proof of its age — Hills south of Kansas river, near the mouth of the Saline. 95 feet.

SYSTEM IV. — TRIASSIC. (?)

No. 2. — Brown sandy shales and marls, with their beds of earthy carbonaceous matter or impure coal. Locality, same as No. 1. 15 feet.

No. 3. — Brown, red, buff, and gray mottled standstone. Locality, Republican, Smoky Hill, Cottonwood, and Fancy Creek. 75 feet.

No. 4. — Brown, drab, reddish, and greenish marls and shales. Locality, same as No. 3. 32 feet.

No. 5. — Fine buff magnesian limestone in thin, hard beds. Locality, Kansas River and Fancy Creek. 6 to 10 feet.

No. 6. — Red, brown, purple, green, blue, and drab argillo-magnesian marls and shales. Some of these beds are intersected by their calcareous plates crossing each other at angles nearly right, forming a cancellated or chambered structure like the cancellated structure of bones a hundred times magnified; the chambers or cells filled with soft clay and lined with crystals and concretions of lime. Locality, same as No. 5. 50 to 90 feet.

No. 7. — White, granular and dark gypsum and fibrous selenite, with marly shale partings. Locality, Kansas and Gypsum Creek. 42 feet.

No. 8. — Red, blue, drab, and purple marls and shales. Locality, same as No. 7. 36 feet.

No. 9. — White and colored gypsum and selenite, interstratified with various colored marls. Locality, Kansas river. 27 feet.

No. 10.[1]—Bluish and brownish drab shales and cancellated marls. Locality, same as No. 9. 25 feet.

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[1] The sandstones, limestones, shales, marls, and gypsums of Nos. 2–10 were referred to the Triassic with a (?) in 1858. The only evidence we then had of the

No. 11. — Fine, hard, black, porous limestone. Locality, head of Turkey Creek.

SYSTEM V. — PERMIAN.

No. 12. — Blue, brown, purple, and drab cancellated marls and shales, containing beds of gypsum and selenite. Locality, same as No. 11. 30 to 40 feet.

No. 13. — Fine, hard, buff and drab magnesian limestone in their beds. *Nuculas* and *Bakevellias.* Locality, same as No. 11. 5 feet.

No. 14. — Brownish and bluish drab cancellated marls. Locality, Turkey Creeks and Cotton Wood. 20 to 30 feet.

No. 15. — *Cancellated Limestone.* Similar in structure to the marls, No. 6, *Bellerophons.* Locality, same as No. 14. 3 to 10 feet.

No. 16. — *Concretionary Limestone.* This is a yellowish drab argillo-magnesian limestone in heavy concretionary beds. Locality, same as No. 14. 2 to 15 feet.

No. 17. — *Calcareous Conglomerate,* — not permanent. Locality, same as No. 16. 1 to 24 feet.

Nos. 15, 16, and 17 — pass into each other by insensible gradations. They are not often found together, and are all well developed.

No. 18. — Black, porous rock, filled with fragments of fossils, wood and other materials. Locality, Turkey Creek. 6 feet.

No. 19. — Drab cancellated marls, interstratified with blue, green, and purple shales. Locality, same as No. 14.

No. 20. — Greyish-buff, *Cellular Limestone.* Locality, Fancy Creek. 2 feet.

No. 21. — Bluish shale. Locality, same as No. 20. 2 feet.

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age of these beds was the position and lithological characters, and a single fossil which could not be distinguished from *Nucula speciosa,* Munster, from the Muschelkalk of Bindloch. Subsequent examinations have strengthened the evidence we then had that this is the true position of these rocks; but still the proof does not amount to demonstration, and it must remain in doubt till other discoveries determine the matter. Our present knowledge is sufficient for all practical purposes, for we know their exact position in the series of rocks in Kansas, and their valuable mineral contents, and the places where the gypsum beds may be found.

No. 22.— Hard, brown-buff cellular limestone. 4 inches.

No. 23.— Bluish drab shale, with calcareous concretions. 3 feet.

No. 24.— Fine bluish-drab and buff magnesian limestone, full of Permian acephala, and *Cephalopods*. Locality, Fancy and Turkey Creeks, and Cottonwood. 6 feet.

No. 25.— Marly Shales. Locality, same as No. 24. 1 to 5 feet.

No. 26.— Hard, grayish and bluish-buff, porous oolitic limestone, full of minute acephala of Permian types. Locality, same as No. 24. 1 to 2 feet.

No. 27.— Brownish-buff magnesian limestone. Fossils same as last. Locality, same as No. 24.. 6 to 12 inches.

No. 28.— Brown, sandy shales filled with *Aviculopecten constens*. Locality, same as No. 24. 6 inches.

No. 29.— Blue and brown shales. *Aviculopecten constens*. Locality, same as No. 21. 6 to 12 feet.

No. 30.— Buff magnesian limestone. Locality, same as No. 24. 6 inches.

Lower Permian.

No. 31.— Brown, red, and blue shales. Numerous *Producti*, *Orthisina*, *Athyris*, *Stenopora Crinoids* and *Cynoclodias*. Locality, same as No. 24. 3 to 20 feet.

No. 32.— Soft, impure, brown, porous magnesian limestone. Locality, same as No. 24. 6 to 8 inches.

No. 33.— Blue and drab marls. Locality, Turkey and Fancy Creeks. 1 to 15 feet.

No. 34.— Hard, blue and dark-buff limestone. *Productus Calhounianus*, *Edmondia Hawni*, *Monotis Hawni*, *Myalina*, *Pinna*, etc. Locality, same as No. 33. 1 to 2 feet.

No. 35.— Blue and brown marls, sometimes cherty. Locality, same as No. 33. 1 to 2 feet.

No. 36.— Blue and brownish-drab, hard or soft limestone. *Monotis*, *Schizodus*, *Bakevellias*, *Pinna*, etc. Locality, same as No. 33. 1 foot.

No. 37.— Shales. Locality, Turkey Creek. 7 inches.

No. 38.— Hard, yellowish-drab magnesian limestone, with dark spot, and dendritic markings. *Monotis*, *Pecten*, *Schizodus*, *Avicula*, etc. Locality, same as No. 37. 1 foot.

No. 39. — Blue, brown, green, and red shales and marls. Many fossils, nearly all of carboniferous genera. Locality, Cottonwood, Carey and Fancy Creeks. 30 to 40 feet.

No. 40. — 1st. *Cherty Limestone* — is a brownish-buff magnesian limestone, with cherty concretions. *Productus Calhounianus, Semireticulatus,* (?) *Athyris Subtilita,* (?) *Archæocidaris.* Locality, Cottonwood and Carey Creeks. 4 feet.

No. 41. — Brown and drab indurated marls with chalcedonic geodes. Locality, Cottonwood and Carey Creek. 6 feet.

No. 42. — Buff and bluish-gray and brown, coarse, porous magnesian limestone, showing sun-cracks and ripple-marks. Locality, same as No. 41. *Archæocidaris, Orthisina, Synocladia, Crinoids,* and *Bulanus.*(?) 4 to 12 feet.

No. 43. — Brown and blue marls. Fossils and locality, same as No. 41. 12 feet.

No. 44. — 2d. *Cherty Limestone* — is hard bluish-drab, and very cherty. *Productus, Myalina,* and *Spirifer.* Locality, same as No. 41. 4 feet.

No. 45. — Brown marls. Fossils and locality, same as No. 41. 8 feet.

No. 46. — Brown and buff cellular limestone. Locality, same as No. 41. 1 foot 6 inches.

No. 47. — Brown, blue, purple, and green shales and marls. *Archæocidiris, Athyris,* and *Crinoids.* Locality, same as No. 41. 42 feet.

No. 48. — Bluish-buff and brown magnesian limestone. Permian *Acephala.* Locality, Carey and Fancy Creeks. 13 feet.

No. 49. — Brown, blue, green, and drab marls and shales, with a few thin beds of limestone. *Thamniscus dubius,* (?) *Monotis Hawni,* etc. Locality, Carey Creek. 41 feet.

No. 50. — Drab and buff magnesian limestone. Permian Fossils — Locality, same as No. 49. 9 feet.

No. 51. — Blue and brown shales and marls. *Athyris* like *Subtilita.* Locality, same as No. 49. 12 feet.

No. 52. — *Fort Riley Limestone.* — This is a buff, porous magnesian rock, in thick beds. *Productus Calhounianus, Othisina, Shumardiana Archæocidaris,* and *Bakevellia,* etc. Locality, near Fort Riley, Cottonwood, Blue and Fancy Creeks. 8 to 10 feet.

No. 53.—Blue and brown shales. Locality and fossils, same as No. 52. 6 feet.

No. 54.—3d. *Cherty Limestone* is light-buff and magnesian. Locality, same as No. 52. *Producta Calhouniana*, *Archæocidaris*, *Spirifer* like *Lineatus*, *Orthisina* like *Umbraculum*. 40 feet.

No. 55.—Brown, blue, and red shales and marls. Locality and fossils, same as No. 52. 20 to 35 feet.

No. 56.—*Myalina Limestone* is a brownish-gray and buff magnesian limestone. Numerous *Myalinas* of Permian forms. Locality, same as No. 52. 4 to 8 feet.

No. 57.—Blue, brown, and red marls and shales. Locality and fossils, same as No. 52. 10 to 25 feet.

No. 58.—4th. *Cherty Limestone* is brown, buff, and porous cherty magnesian limestone. Locality, sand fossils nearly, the same as No. 54. 10 to 24 inches.

No. 59.—Blue, drab, and brown marls and shales. *Orthis*, *Chonetes*, *Arca*, and *Crinoids*. Locality, same as No. 52. 8 to 21 feet.

No. 60.—Thin sandy argillo-calcareous shales, full of Permian *Acephala*. Locality, near Fort Riley. 3 feet.

No. 61.—Bluish-brown shales. *Chonetes* and *Productus*. Locality, same as No. 60. 3 feet.

No. 62.—5th. *Cherty Limestone* is a light drab and buff cherty magnesian limestone. *Productus Calhounianus*, *Chonetes*, *Mucronata*, *Orthisina* like *Umbraculum*, *Athyris* like *Subtilita* and *Crinoids*. Locality, same as No. 60. 12 feet.

No. 63.—Brown, bluish-drab, green and purple shales and marls. *Synocladia biserialis*, *Productus Norwoodi*, *Orthisina Shumardiana*, etc. Locality, same as No. 60. 11 to 23 feet.

No. 64.—Impure brown, porous limestone, with dark dots and dendritic markings. Locality, same as No. 60. 4 feet.

No. 65.—Blue and brown marls and shales. Locality, same as No. 60. 15 to 30 feet.

No. 66.—Light buff and drab argillo-magnesian limestone, in thin beds, with dark dendritic markings—*Monotis* and *Bakevellia*. Locality, same as No. 60. 15 to 18 feet.

No. 67.—Blue and drab shales and marls. Locality, same as No. 60.

No. 68.—Hard blue and buff magnesian limestone, containing numer-

ous Permian *Acephala*. Locality, Cottonwood and Clark Creek. 1 to 3 feet.

No. 69.— Drab shaly marls. 5 feet.

No. 70.—Hard blue and drab mottled porous limestone. 1 foot 6 inches.

No. 71.— Brown, blue, and reddish marls. Locality, Clark Creek. 5 feet.

No. 72.— Bluish-gray limestone. Locality, Clark Creek. 3 inches.

No. 73.— Brown and purple mottled shales. 7 feet.

No. 74.— Hard, brown and blue limestone. 10 inches.

No. 75.— Blue shales. 5 inches.

No. 76.— *Coraline Limestone*. Soft blue and gray limestone. *Monotis Halli* and *Americana*, *Productus Norwoodi*, *Synocladia*, *biserialis*, *Thamniscus dubius*, (?) *Edmondia Hawni*, *Phillipsia Cliftonensis*, etc. Locality, Cottonwood and Clark Creek. 3 feet.

No. 77.— Blue, brown, and purple shales and marls. Locality, same as No. 76. 9 feet.

No. 78.— Gray and drab porous limestone. Locality, same as No. 76. 2 feet.

No. 79.— Blue, brown, and purple marls, some very much cancellated and a few beds of thin limestone. *Chonetes*, *Productus costaloides*, *Orthisina Missouriensis*, *Synocladia biserialis*, *Archæocidaris* and *Euomphelus*. Locality, same as No. 76. 38 feet.

No. 80.— *Fusulina Limestone*, buff, porous, and magnesian. *Productus*, *Chonetes*, *Allorisma*, *Fusulina*, etc. Locality, Manhattan, Cottonwood Falls, and Mill Creek. 6 feet.

No. 81.— Blue, brown, purple, and green shales and marls, with calcareous concretions and thin consolidated strata. *Monotis*, *Edmondia*, *Myalina*, *Pecten*, *Allorisma*, and *Bellerophon*, nearly all Permian types. 31 feet.

No. 82.— *Cotton Rock*, a light cream colored argillo-magnesian limestone, sometimes in thin beds with shale partings. It has numerous dendritic markings. *Spirifer*, *Athyris*, *Fusulina*, *Productus*, and *Crinoids*. Locality, Manhattan and Mill Creek. 5 feet.

No. 83.— Bluish-brown marls. 1 foot.

No. 84.— "*Dry bone Limestone*" — brown concretionary and can-

cellated limestone. *Synocladia biserialis*, *Spirifer plano-convexa*, etc. 5 to 15 feet.

Nos. 82, 83, and 84 are sometimes represented by a bluish-gray and buff porous magnesian limestone, upper beds thick, below thin beds separated by cellular partings, containing numerous Permian *Acephala* and *Zaphrentis* and small *Spirifer*. Locality, Cottonwood.

SYSTEM VI.—CARBONIFEROUS.

F *a*—COAL MEASURES.

No. 85.—Brown indurated and cancellated marls. *Spirifer plano-convexa* and *cameratus* (long variety), *Fusulina*, etc. Locality, Manhattan and Cottonwood. 2 feet six inches.

No. 86.—Hard buff and gray limestone filled with fragments of fossils. Locality, same as No. 85. 1 foot 3 inches.

No. 87.—Buff, brown, and blue marls and shales. 8 feet.

No. 88.—Impure, soft brown and buff argillo-magnesian limestone. Locality, same as No. 85. 5 feet.

No. 89.—Brown shaly marl. 1 foot.

No. 90.—Blue and brown mottled limestone. 1 foot.

No. 91.—Brown, drab, green, and purple marls and shales. *Retria punctilifora*, *Monotis*, and *Edmondia*. 19 feet.

No. 92.—Fine drab magnesian limestone. 10 inches.

No. 93.—Blue, green, drab, brown, and purple shales and marls; sandy shales near top and black slate near bottom. *Athyris subtilita*, *Archæocidaris aculeatus*. Locality, same as No. 85. 38 feet.

No. 94.—Brown sandy shales. Locality, same as No. 85. 6 feet.

No. 95.—Brown calcareous sandstone with crystals of calc-spar. Locality, Manhattan. 3 to 4 feet.

No. 96.—*Fusulina Shales*. Dark-blue marly shale. Numerous *Fusulinas* and *Carboniferous Brachiopoda*. Locality, Manhattan, Cottonwood and Mill Creek. 12 feet.

No. 97.—Black Slate. *Fish scales* and *Discina Missouriensis*. 1 foot.

No. 98.—Coal. Locality, Manhattan and Mill Creek. 1 to 3 inches.

No. 99. — Impure brown limestone. *Fish teeth.* 1 foot.

No. 100. — Blue and brown shales. 5 feet.

No. 101. — Impure buff magnesian limestone. Many *Fusulinas.*

No. 102. — Blue, brown, and purple shales. 25 feet.

No. 103. — Hard blue limestone. *Productus* and *Crinoids.* 1 foot.

No. 104. — Black, brown, and blue shales. 2 feet.

No. 105. — Impure bluish-brown limestone. *Hydraulic, Productus, Chonetes, Spirifer,* and *Orthisina.* 10 inches.

No. 106. — Blue, brown, and purple marls and shales, some sandy shales in thin strata. Locality, same as No. 98. 35 to 43 feet.

No. 107. — Hard, drab, bluish and porous magnesian limestone. Permian *Acephala.* (?) 2 to 3 feet 6 inches.

No. 108. — Drab, blue and greenish marls, often filled or replaced by black, white, buff and yellow selenite. Locality, same as No. 98. 1 foot 6 inches.

No. 109. — Impure dark-brown shaly limestone. *Carboniferous fossils.* 6 inches.

No. 110. — Dark-blue and drab shales. 2 feet.

No. 111. — Impure shaly limestone. *Fucoids.* 10 inches.

No. 112. — Blue shale. 1 foot.

No. 113. — Coal. 1 to 3 inches.

No. 114. — Blue shale. 2 feet 6 inches.

No. 115. — Oxide of Iron — Local. 3 inches.

No. 116. — Impure brown magnesian limestone. 1 foot.

No. 117. — Blue and brown argillo-arenaceous shales and marls. Locality, same as No. 98. 17 feet.

No. 118. — Blue and brown impure limestone. (*Hydraulic.*) 1 foot 3 inches.

No. 119. — Blue, brown, and black shales. 9 feet.

No. 120. — Blue and drab magnesian marls, containing crystals of black selenite. Numerous *Acephala* and *Cephalopoda.* Some like Permian types. Locality, Zeandale, and Mill Creek. 15 feet.

No. 121. — Hard, crystalline, grayish-blue limestone, with black dots and dendritic markings. Numerous small *Acephala* and *Cephalopoda.* Some like Permian types. Locality, same as No. 120. 2 to 10 inches.

No. 122. — Blue, drab and brown magnesian shales. Fossils and locality, same as No. 120. 6 feet.

No. 123. — Hard, fine, reddish-brown and gray spotted limestone. 2 feet.

No. 124. — Drab, blue brown and grayish shales. 4 to 6 feet.

No. 125. — Buff and brown soft argillo-calcareous sandstone. The lower part is calcareo-magnesian, full of chocolate-colored pores and small masses of oxide of iron, — colors and pores arranged in thin strata which separate on exposure. Locality, Mill Creek. 1 foot 8 inches.

No. 126. — Green, drab, and purple shale. 12 feet.

No. 127. — Impure brown porous limestone, and greenish-drab porous marls. *Productus*, *Retria*, *Spirifer*, *Orthisina*. Locality, same as No. 121. 1 to 2 feet 6 inches.

No. 128. — Blue, brown, and purple shales and marls. Fossils and locality, same as No. 121. 33 feet.

No. 129. — Coal. 4 to 10 inches.

No. 130. — Fire clay. 6 inches.

No. 131. — Brown and blue sandstone and shale. Locality, Mill Creek. 21 feet.

No. 132. — Impure brown and greenish-gray hydraulic limestone. *Productus*, *Chonetes*, *Pinna* and *Fusulina*. Locality, same as No. 131. 1 foot 3 inches.

No. 133. — Blue argillaceous and sandy shales. 6 feet.

No. 134. — *Chætetes Limestone.* This is a fine, hard, porous, impure limestone, varying in color from gray through ochreous brown to chocolate. The lower part is firm and brown, and the upper beds are blue and argillaceous. *Fusulina*, *Myalina*, *Zaphrentis*, *Crinoids* and a *Chætetes* in irregular masses, or formed around a *Zaphrentis* or a *Crinoid* column. Locality, Mill Creek and Eastward.

No. 135. — Brown and blue shales and marls, with calcareous concretions and bands of kidney ore. Locality, same as No. 134. 45 feet.

No. 136. — Brown and bluish-gray limestone in one bed. *Chonetes* and *Crinoids*. Locality, same as 134. 1 foot 8 inches.

No. 137. — Blue and brown shales. 10 feet.

No. 138.—Hard, dark, ochreous, brown limestone Locality, near Baptist Mission. 2 feet.

No. 139.—Shale. Locality, same as No. 138. 5 feet.

Chocolate Limestone Series.

No. 140.—*Chocolate Limestone.* This is a coarse, rough, porous gray and chocolate limestone, full of a very large ventricose *Fusulina*, *Productus Americanus*, *Calhounianus* and *cora*, *Zaphrentis* and *Crinoids.* Locality, Mill Creek and Eastward. 6 feet.

No. 141.—Blue and brown sandy shales. Fossils and locality, same as No. 140. 11 feet.

No. 142.—Thin, brown, impure limestone and calcareous sandstones, with shale partings. Locality, Verdigris Falls and west of Baptist Mission. 8 feet.

No. 143.—Purple and blue shales. Locality, same as No. 142. 18 feet.

No. 144.—Brown micaceous sandstone. 3 feet.

No. 145.—Blue, drab, red and gray limestone, passing into sandstone. Numerous *Corals* and *Brachiopoda.* 8 feet.

No. 146.—Brown shales. 3 feet.

No. 147.—Bituminous shale. 4 feet.

No. 148.—Gray, buff and brown limestone, passing into brown sandstone below in some places. Numerous *Corals* and *Brachiopoda.* 9 feet.

No. 149.—Brown shales and sandstones. Numerous *Corals* and *Brachiopoda.* 9 feet.

Stanton Limestone Series.

No. 150.—*Stanton Limestone.* Rather coarse drab magnesian and brown limestone. *Productus Americanus*, *Athyris Subtilita*, and *Archæocidaris*, etc. Locality, Mission Creek, Marais Des Cygnes, and Verdigris. 6 to 28 feet.

No. 151.—Argillaceous shales and sandstones. Locality, Marais Des Cygnes and Verdigris. 8 feet.

No. 152.—Blue pyritiferous shales. Locality, Verdigris. 9 feet.

No. 153.— Bituminous coal. Locality, Marais Des Cygnes and Verdigris. 1 foot to 2 feet 6 inches.

No. 154.— Gray and brown sandstone and shales. Locality, same as 158. 12 to 50 feet.

CAVE ROCK SERIES.

No. 155.— *Cave Limestone.* Bluish-gray and brown jointed limestone, with marly partings in places. *Spirifer hemplicata*, *Productus*, *Athyris*, *Crinoids*, etc. Locality, Beaver Creek, Sugar Creek, and Lecompton. 15 to 30 feet.

No. 156.— *Einstein Sandstone* is a blue, brown, and gray sandstone and shale. Locality, same as No. 155. 45 to 60 feet.

SPRING ROCK SERIES.

No. 157.— Gray limestone, spotted with brown in thin irregular beds. Locality, same as No. 155. 2 feet.

No. 158.— Sandstone and shales. Locality, same as No. 156. 15 to 25 feet.

No. 159.— Coal. Locality, Bull and Middle Creeks, Miami County. 4 to 8 inches.

No. 160.— *Fire Clay.* Locality, same as No. 159. Nos. 158, 159, 160 are often replaced by a bluish-brown shale, filled with calcareous concretions. 4 feet.

No. 161.— *Spring Rock.* A hard bluish-gray and brown limestone. Locality, Beaver Creek, Marais Des Cygnes, and Johnson's Creek, west of Topeka and Lecompton. 1 to 4 feet 8 inches.

No. 162.— Brown sandstones and blue shales, interstratified. Locality, same as No. 161. 4 to 38 feet.

No. 163.— Bituminous coal. Locality, West of Baptist Mission, at Johnson's coal bed, west of Topeka. 6 in. to 1 foot 6 in.

No. 164.— Fire clay. Locality, same as No. 161. 1 foot.

No. 165.— Blue shales and brown sandstones, and bands of kidney ore. Locality, West of Baptist Mission, at Lecompton, and Beaver Creek. 35 feet.

Well Rock Series.

No. 166. — Blue and gray limestone and porous chert, in thin beds interstratified with shales. *Spirifer* and *Productus*, *Athyris*, etc. Locality, Lecompton, Middle Creek, and Marais Des Cygnes. 5 to 7 feet.

No. 167. — Blue shales. Locality, same as No. 166. 13 feet.

No. 168. — *Well Rock.* — Light-gray and hard brown limestone, with cherty concretions. When fully developed the upper part is coarse and porous, in heavy bands, numerous *Corals* and *Brachiopoda.* Locality, Paris, Lawrence, Garnett, Ottawa, and Leavenworth. 10 to 48 feet.

No. 169. — Brown and blue shales and fine bluish-gray limestone, interstratified (in places all shale). *Productus*, *Chonetes*, *Spirifer*, *Corals*, and *Crinoids.* Locality, same as No. 166. 2 to 6 feet.

No. 170. — Bituminous shale. *Discina* and *Turbo.* Locality, same as No. 166. 6 feet 6 inches.

No. 171. — Hard, firm, blue limestone. *Spirifer lineatus.* Locality, same as No. 166. 1 to 3 feet 3 inches.

No. 172. — Blue and brown shales. Locality, same as No. 166. 1 to 4 feet.

No. 173. — Brown and gray cherty limestone, with shale partings. Numerous *Corals* and *Brachiopoda.* Locality, same as No. 166. 10 to 15 feet.

No. 174. — Blue and brown shales and brown and gray shales and sandstones, with bands of iron ore. Locality, same as No. 166. 75 to 100 feet.

No. 175. — Bituminous coal. Locality, Center Creek, west of Lawrence. 1 to 5 inches.

No. 176. — Brown, green, and purple shales and marls, and buff and gray sandstones. Locality, same as No. 166. 55 to 90 feet.

Marais Des Cygnes Coal Series.

No. 177. — Hard, fine, blue limestone, with jointed structure, *Spirifer lineatus*, *Athyris subtilita* and *Crinoids.* Locality, Sugar and Mine Creeks, Linn Co. 2 to 4 feet.

No. 178. — Brown sandstones, and blue shales, and bands of iron ore. Locality, same as No. 177. 38 to 51 feet.

No. 179. — Bituminous coal. Locality, same as No. 177. 2 inches.

No. 180. — Blue and black shale. Locality, same as No. 177. 3 feet.

No. 181. — Bituminous coal. Locality, same as No. 182. 1 foot 8 inches to 2 feet 9 inches.

No. 182. — Black shale and fire-clay. Locality, Linn Co. 3 feet.

No. 183. — Impure brown and bluish-gray limestone. *Spirifer*, *Productus*, *Chonetes*, *Myalina*, *Pecten*, etc. Locality, Sugar Creek and Lawrence. 6 feet.

No. 184. — Brown and buff regularly stratified sandstone. Locality, Muddy Creek, Linn Co. 45 feet.

No. 185. — Blue shales and marls. Locality, Mound City and Muddy Creek. 25 feet.

No. 186. — Brown and bluish-gray limestone, with shale partings and numerous fossils. Locality, same as No. 185. 12 feet.

No. 187. — Blue and brown shaly marls. Locality, Marais Des Cygnes and Mine Creek. 2 feet.

No. 188. — Fine, bluish-drab, concretionary limestone. Locality, same as No. 187. 4 feet.

No. 189. — Brown and bluish sandstone and shales.[1] Locality, Marais Des Cygnes and Mine Creek. 45 feet.

No. 190. — Coal. Locality, same as No. 189. 1 foot 6 inches to 2 feet.

No. 191. — Black slate and fire-clay. 2 feet.

No. 192. — Bluish-drab compact limestone, with very large masses *Chætetes*. Locality, Marais Des Cygnes and Indian Creek. 5 feet.

No. 193. — Brown and drab shales, containing numerous concretions. Locality, Mill Creek, in Bourbon Co. 15 feet.

No. 194. — Blue, green, brown, and chocolate shales and marls. Locality, same as No. 193. 30 feet.

No. 195. — Sandy shales. Locality, same as No. 193. 10 feet.

No. 196. — Brown, and dull brownish-drab sandstone in regular beds. *Calamites*. Locality, same as No. 193. 11 feet.

No. 197. — Brown and drab sandy shales. Locality, same as No. 193. 8 feet.

No. 198. — Blue shales, with bands of kidney ore. 17 feet.

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[1] Mine-Creek Lead Mines are in these rocks.

No. 199. — Bituminous and pyriliferous shale. 1 foot.

Nos. 193–199 are represented by 45 feet of blue and brown shales, with bands of kidney ore on the Marais Des Cygnes, at Root's Coal Bed.

No. 200. — Coal. Locality, same as No. 193 and Marais Des Cygnes, and Mound City. (?) 2 to 3 feet.

No. 201. — Fire-clays and shales. 5 feet.

Pawnee Limestone Series.

No. 202. — *Pawnee Limestone*[1] is heavy-bedded, porous and compact, coarse and fine, drab, brown and bluish-gray, cherty, concretionary and mottled. *Chætetes* and *Crinoids*, etc. Locality, Indian and Pawnee Creeks, and south to Bone Creek. 20 to 55 feet.

No. 203. — Dull, brownish-blue, hydraulic, concretionary limestone, with pyriliferous shale partings. Locality, same as No. 202. 6 feet.

No. 204. — Black slate. *Discinas*. Locality, same as No. 202. 2 to 4 feet.

No. 205. — Blue and brown argillo-sandy shales. Locality, on the Marmiton, above Fort Scott and Indian Creek. 5 feet.

No. 206. — Impure black shaly limestone full of fossils, and a bed of cone — in cone. Locality, same as No. 205. 6 inches.

No. 207. — Blue and brown argillo-sandy shales, with thin bands of brown limestone and septaria of iron ore. Locality, Indian and Wolverine Creeks. 34 feet.

No. 208. — Black, impure shaly limestone, full of fossils. *Spirifer*, *Productus*, and *Chonetes*. Locality, same as No. 206. 1 foot.

No. 209. — Coal and coal smut. Locality, same as No. 206. 6 inches.

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[1] The lower part of this limestone is almost exactly like the Fort Scott limestone, both in lithological characters and fossils; hence it is very difficult to distinguish them when the upper gray beds of this limestone and the shales below are not exposed. Between Indian Creek and the Marmiton, both of these rocks crop out in the numerous ravines and slopes, and they are very much broken and disturbed, making it almost impossible to make a correct section of the rocks between those streams without this knowledge of the similarity of these limestones.

No. 210.— Brown and blue argillo-sandy shales, with a few bands of iron ore. 25 feet.

Fort Scott Coal Series.

No. 211.—*Fort Scott Limestone* is a bluish-drab and brown, irregularly bedded limestone, with many *Producti*, *Chonetes*, and *Spirifers*. Locality, Little Osage, Fort Scott, and south to Dry-wood and Bone Creek, and west to the Neoshe. 8 to 18 inches.

No. 212.— Dark brown shales and marlites and iron-stone. Locality, same as No. 211. 2 feet.

No. 213.— Black slate. Locality, same as No. 211. 4 feet.

No. 214.— Coal. Locality, same as No. 211. 6 inches.

No. 215.— Gray, blue, and brown fire-clays and shales. 5 to 8 feet.

No. 216.— Impure brown and drab hydraulic concretionary limestone in one thick bed. *Productus*, *Spirifer*, *Crinoids*, etc. Locality, same as No. 211. 6 feet.

No. 217.— Black slate containing large concretions of iron-stone. 4 feet.

No. 218.— Coal. Locality, same as No. 211. 1 foot 4 inches.

No. 219.— Fire-clay. 4 feet.

No. 220.— Impure brown mottled limestone. *Spirifer* like *Cameratus* but new. Locality, only on Drywood. 2 feet.

No. 221.— Drab and bluish fire-clays. This bed often passes into sandstone or sandy shales. Locality, same as No. 211. 12 feet.

No. 222.— Blue and brown drab argillo-sandy shales, with sandstone layers and numerous beds of good iron ore. Locality, same as No. 211. 87 feet.

Fort Scott Marble Series.

No. 223.— Hard, fine, black limestone. Locality, Little Osage, near State line. 3 feet.

No. 224.— Black slate. Locality, same as No. 223. 5 feet.

No. 225.— Blue and yellow shale. Locality, same as No. 223. 7 feet.

No. 226. — *Fort Scott Marble* is black, with numerous yellowish veins and crystallized shells, and it weathers brown. It takes a good polish. Locality, "Slick-Rock Ford," on the Marmiton, and on Moor's Branch above the "Military Ford." 1 foot 6 inches.

No. 227. — Blue and brown shales. 1 foot 8 inches.

No. 228. — Black slate. Locality, same as No. 226. 2 feet.

No. 229. — Coal, good. Locality, Little Osage, below State line. 2 feet 6 inches.

Lower Coal Series.[1]

No. 230. — Long slope to Middle Fork of Cow Creek, probably sandstone and shale, and two beds of coal, one and two feet in thickness. 25 to 50 feet.

No. 231. — Brown sandstone and sandy shales and iron ore. Locality, Dorsey's, on Middle Fork of Cow Creek. 10 feet.

No. 232. — Brown and bluish argillo-sandy shales, with dark partings. Locality, same as No. 231. 12 feet.

No. 233. — Brown and bluish argillo-sandy shales, with dark partings. Locality, same as No. 231. 12 feet.

No. 234. — Bituminous Coal.[2] Locality, Dorsey's Coal Bank. 5 to 7 feet.

No. 235. — Slope on East Fork, or Little Cow Creek. 10 feet. (?)

No. 236. — Hard, brown and gray sandstone in thick beds, with jointed structure and shale partings. Locality, same as No. 234. 20 feet.

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[1] The south-eastern part of the State, the only place where the lower coal-rocks come to the surface, is so level and the slopes are so gentle, and the soft shales and sandstones are so abundant, that the rocks are but rarely exposed; and the exposures are so small and so far from each other, that it is very difficult to make a connected section with absolute certainty. We could expect to make only an approximation to a connected section in the few days devoted to this interesting region; but, whenever any uncertainty exists in the rocks or their connections, it is fully indicated in the text. If more time could be devoted to this region, a connected section could be made of this important part of the coal series.

[2] We saw but four feet of this coal, as the bank was caved in; but it is reported to be seven or eight feet thick in places.

No. 237.—Sandy and argillaceous shales. 10 feet.

No. 238.—Coal and coal smut. 2 to 6 inches.

No. 239.—Shales and sandstone. Locality, Military Ford, on Cow-Creek. 15 feet.

No. 240.—Red and brown shales with kidney ore. Locality, Shawnee Creek. 20 feet.

No. 241.—Brown, hard, ripple-marked sandstone, with shale partings. Locality, Brush Creek and Mound, 6 miles west of Baxter's Spring.

No. 242.—Blue and brown shales, with black partings and numerous bands of iron ore. Locality, same as No. 241. 35 feet.

No. 243.—Coal and coal smut. Locality, same as No. 241. 2 to 8 inches.

No. 244.—Blue and brown shales. Locality, same as No. 241. 50 feet.

No. 245.—Slope, probably sandstone and shales. 20 to 30 feet.

No. 246.—Brown micaceous sandstone, some irregular, thick, soft beds and some shale partings below. *Calamites.* Locality, Neosho, 3 to 5 miles above State line. 40 feet.

No. 247.—Gray and brown sandstone and kidney ore. Locality, on the Neosho at the State line, and 3 miles above. 2 feet.

No. 248.—Blue shales with black partings, and many bands of iron ore, of which hundreds of tons are washed out on the Neosho, near the State line. Locality, same as No. 248. 12 feet.

No. 249.—Black and gray calcareous shaly limestone, full of fossils. *Productus Chonetes, Orthisina, Spirifer, Corals, Crinoids,* etc. Locality, same as No. 248. 8 inches.

No. 250.—Blue and black shale. Locality, same as No. 248. 2 feet.

No. 251.—Coal. Locality, same as No. 248. 4 to 10 inches.

No. 252.—Blue, brown, and black shales. 16 feet.

No. 253.—Space in which the rocks were not seen. 25 feet. (?)

F *b.*—Lower Carboniferous.

No. 254.—Slope covered by fragments of chert and cherty ferruginous conglomerate and clays. Locality, Baxter's Spring and Branch. 10 feet.

No. 255.—Gray and bluish-gray crystalline and granular limestone,

with intercallation of chert and hornstone. *Spirifer*, *Productus*, *Chonetes*, *Platycrinus*, and *Zaphrentis*. Oldest rock in Kansas. Locality, Baxter's Spring and Branch to Spring River. 110 feet.

REMARKS ON THE ABOVE SECTION.

Tertiary System.

The rocks of this system are known to occupy a considerable portion of Western Kansas; but we have had no opportunity of examining these formations, and therefore cannot give any detailed description of them. The most important fact known respecting this series of rocks is that it contains extensive beds of *Brown Coal*, or *Lignite*, which must be very valuable for fuel in a region possessing so little timber. They crop out along the Smoky Hill, and render that beautiful valley most desirable for agriculture, railroads, and manufactures; whereas, without these beds of fuel, this valley must have remained but sparingly populated for centuries to come.

Cretaceous System

Also underlies a large portion of Central Kansas. The ferruginous sandstones, which cap the hills and ridges in Central Kansas, have been referred to this system; whether correctly so must be determined by the examination of localities beyond the range of our explorations during the past year; the cretaceous rocks, however, are known to exist in considerable force in Central Kansas.

Triassic System. (?)

There is a series of buff, red and mottled sandstones, red and drab marls, buff, magnesian and black limestones, blue and brown shales and gypsum, 344 feet in thickness, under the sandstone of the cretaceous (?) and over the rocks known to be Permian. As a sufficient number of fossils had not been found in these strata to fully decide the exact age to which they belong, and as they resembled, in lithological and palæontological characters, the Triassic rocks of Europe more

than any others, they were placed promiscuously in that group by Maj. Hawn and myself, in 1858; and as the facts and few imperfect fossils found since rather sustain this classification, it is not deemed advisable to make any change in the arrrangement until future discoveries shall fully establish their position in the geological ages.

It should be remembered, however, that the uncertainty about the age of these rocks does not in the least interfere with our fully understanding the mineral wealth contained in them, nor with our ability to fully develop it; for we know the exact position of these rocks [1] in the series, the strata of which they are made up, and the valuable minerals they contain, and their wonderful fertilizing influence over the soils which rest upon them or come within the range of the waters that flow from them.

These rocks extend in an irregular belt across the State, from the head-waters of the Blue and Fancy, across the Republican and Solomon and over the Kansas, between Turkey Creek and the Saline; thence south and south-easterly up the Smoky Hill and Gypsum, Holland and Turkey Creeks; along the northern slope of the divide, south of the Kansas, to the heads of Lyon and Diamond Creeks; sweeping thence westward across the Cottonwood and down the divide, south of that stream, to the Walnut and White Water.

The gypsum beds in this location are variable in thickness, ranging from 0 to 50 feet. Deposits of pure white gypsum crop out on the Blue, the Republican, and the Kansas, and on Turkey Creek; and on the divides between the Gypsum and Holland, and between Turkey Creek and the Cottonwood. The beds at the four last localities are very thick and miles in length. There are doubtless many other localities between the range of those rocks where these gypsums come to the surface, and which a more careful examination will develop.

Permian System.

There is a series of limestones, marls, shales, sandstones, conglomerates, and gypsums, below the Triassic group described above, which belong to the same age as the Permian Rocks of Europe.

Since the true position of these rocks was first announced [2] in 1858,

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[1] See above section, Nos. 2–10.

[2] This discovery was first announced by myself February 22, 1858. See Trans. Acad. Nat. Science, St. Louis. Vol. I.

the proofs of their identity with the Permian system have been constantly accumulating, until at the present time there is probably no geologist who has examined the matter and still doubts their identity with the Permian of Europe.

We have made two divisions of those rocks in reference to the fossils they contain. The upper division comprises the limestones, marls, shales, conglomerates, sandstones, and gypsums in Nos. 12–30 of the section above, representing a thickness of 148 feet. The fossils of these strata, so far as observed, belong to the *Acephala* and *Cephalopoda* and *Gastropoda*, and no one of them has been identified with known Carboniferous species.

In lithological characters these rocks are very similar to the rocks of the same age in Europe. The magnesian limestones and conglomerates, the various colored marls and shales, and the gypsums, all and each would well answer the descriptions given of the same rocks in Europe.

These rocks occupy a narrow belt across the State, east of the Triassic group, as described above.

This formation also contains beds of gypsum, which, together with the marls found in all parts of the series, have a most beneficial influence upon the soils, and will, to a great extent, control the productions, population, and wealth of Central Kansas.

LOWER PERMIAN.

This series, like the Upper Permian, is made up of a succession of magnesian limestones, blue, drab, red and green marls and shales, red and buff sandstones and conglomerates and gypsums; but there are more blue shales, like those in the coal-measures below. These rocks contain nearly or quite all the fossils found in the Upper Permian, and in addition a few species [1] common to the upper coal-measures, and perhaps a very few not found above or below.

It is a remarkable fact that the Permian and Carboniferous types

[1] In 1858 I expressed the opinion, based upon the collection sent me by Maj. Hawn, that "although the Permian *species* are so much more numerous, the Carboniferous *specimens* are much the more abundant." But, after a personal examination of these rocks, I am fully satisfied that the Permian fossils are by far the most numerous even in the lowest strata.

are seldom if ever mingled in the same stratum, though both occur in thin beds alternating with each other. The Carboniferous forms usually occur in blue argillaceous shales and in the blue limestones, and the Permian in the magnesian and sandy limestones and drab magnesian shales and marls; so that the character of the fossils follows the lithological characters of the rocks in which they occur. Wherever the rocks are of a Carboniferous character we may expect to find fossils of Carboniferous types, and where the rocks are of a Permian character the fossils are also Permian.

The magnesian material and Permian fossils increase towards the south. They are much more abundant on the Cottonwood than on the Kansas and the Blue. Shales and Carboniferous fossils are not so fully developed on the former stream.

A large number of these strata exhibit indications of shoal water in the sun-cracks, ripple-marks, and small piles of fossils and fragments washed together on their surfaces.

These Permian strata so graduate into and are so nearly conformable to the coal-measures below, that no want of conformability can be detected by examining any one locality, though the line of junction be traced a long distance; yet, where sections are made across the line of junction, at distant points, it becomes evident that there is a striking non-conformability. When the sections made across this line on the Kansas, at Manhattan and above, are compared with those on the Blue, though separated several miles, there is no difficulty in identifying all the important strata in one with those in the others, and when these sections are compared with those on Mill Creek, some 25 miles east, and those on the Cottonwood, 60 miles south from Manhattan, the prominent beds are easily identified down to the lowest bed of the Permian, No. 84 of the above section; but Nos. 85–95 from the sections near Manhattan are not found in the Mill Creek sections, where No. 84 rests directly upon the Fusulina shales, No. 96. These facts present a striking illustration in our geology of Prof. Sedgwick's remarks on the Permian of England: —

"Through many large tracts of country . . . . it (the Magnesian limestone) rests on the coal-measures, and seems to partake of their dip and inclination. It is therefore only after an extensive comparison of the two formations that we can make out their general want of conformity." — (Geological Trans., Vol. III., 2d Sec., p. 56.)

In another paper: —

"Again, though the lower red sandstone of Yorkshire and Durham appears in some cases to graduate into the coal-measures . . . ; yet, when considered on a great scale, it is unconformable to them, and on that account was separated from them." (Geological Trans., Vol. IV., 2d Sec., p. 397.)

These extracts express the facts as they exist in Kansas, and give one good reason why the line of separation should be made where it is. But the main reason for the separation here is the fact that the Permian fossils come down in force to this line and but few go below; while a few species only of Carboniferous fossils are found above it, and in the shales immediately below there are at least thirty species and millions of specimens.

The rocks also change in lithological characters. The blue shales increase; the limestones are less magnesian and more argillaceous and ferruginous;[1] dark, nearly black, fossiliferous argillo-shaly limestones and thin bands of spathic iron come in; bituminous shales and thin coal-beds begin to appear; and the marls, limestones, and shales below no longer present the marked cancellated structure so characteristic of those rocks above.

CARBONIFEROUS SYSTEM.

Coal-Measures.

This formation occupies the surface of nearly all Kansas east of the eastern boundary of the Permian rocks (an area of over 17,000 square miles). This boundary crosses the State in an irregular line from a

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[1] The magnesian limestones weather white, while the ferruginous become brown on exposure. This change in the color of the surface limestones is very obvious to one passing over the line between these formations. One travelling from the Missouri to Manhattan on the north side of the Kaw, or to near Wabaunsee on the south, over the coal-measures, will find nearly all the limestones brownish; but at those points he will find the limestones in the tops of the hills white, and nearly all between these points and the Triassic sandstones near Salina are of the same color. The same facts may be observed on the Blue, on Mill Creek, on the Cottonwood, and the Verdigris. These changes are so obvious that men unacquainted with geology have observed and mentioned them.

point on the northern boundary near the 96th parallel, through Manhattan and Emporia, and thence south across the head-waters of the Verdigris and Fall River.

The coal-measures are made up of numerous limestones and sandstones, shales and marls, spathic iron, fire-clay, and coal, Nos. 85, 254, of the above section. These strata lie in a position nearly horizontal, with numerous undulations and a slight general dip to the west, showing no signs of local disturbances save in a few localities. The most important ones observed were between the Marais Des Cygnes to Fort Scott, where the strata are often fractured and tilted up by some forces not now in action.

The lowest of these strata come to the surface in the south-east, and as the country rises to the north-west the higher beds successively come to the surface, resting upon those below until they reach a thickness of 2000 feet,[1] as measured along the outcropping edges. The relative position of these strata may be well illustrated by the courses of shingles on a roof, only the lower shingles should be long enough to reach the ridgepole under the upper layers, as the lower rocks probably do in their western extension.

Nearly all the important beds of limestone become thicker towards the south and east,[2] where they come to and occupy the surface. Towards the west and north these limestones are hard, subcrystalline, bluish-gray, or brown and cherty, and this part of these beds remains very persistent, while the increased thickness to the east and south is produced by the addition of higher massive beds of coarser gray and buff porous magnesian limestones, more or less stained with iron, especially in the pores. These upper beds usually appear as if made up in part of small fragments of fossils and other calcareous matter. They also contain fossils, which run through this portion of all the limestones thus

[1] Though this is the measured thickness of the coal strata, they will not be found so thick at any given point, for in the east some of the upper beds are wanting, and in the west, where all are present, they are not so thick as at their outcrops, where the measurements were made.

They cover the surface over an area of 17,000 square feet, and then run beneath the Permian rocks westward.

[2] As an illustration, the thickness of the *Well Rock*, No. 166, is only 10 feet at the Ferry near Lecompton, while on Sugar Creek, in Anderson Co., it is 48 feet. The thickness of the *Stanton Limestone*, No. 151, is only 6 feet at the Baptist Mission in Shawnee Co., but on the Marais Des Cygnes, in Miami, it is 18 feet.

thickened, and are more abundant in them than elsewhere, or even in the lower portions of the same formations. Two or three species of *Archæocidaris* and a large *Athyris* are abundant and *Productus Americanus* more rare in these beds.

The sandstones and sandy shales are also thicker towards the south-east, and are more generally irregular than any others of these formations, — old beds thinning out and new ones coming in between the more persistent and regular strata of shales and limestones.

These characteristics being so common to the upper beds of so many of the limestones make it very difficult to distinguish these beds from each other and keep the true position of each throughout the vast extent of country over which some of them come to the surface. The *Well Rock* crops out on Sugar Creek, in Anderson Co., as a coarse gray, rough limestone, 48 feet thick, at the ford of the Marais Des Cygnes, on the "Telegraph Road." It is a fine drab compact limestone, 8 feet thick, with an entire new set of fossils. Thence it may be traced from stream to stream and slope to slope, till found near high-water mark at Lecompton, and in the tops of the ridges at Lawrence. This last position it holds in the ridges to Leavenworth, where it is bluish-gray, brown, and subcrystalline.

The coal-beds are also thicker towards the south and east, though there are exceptions; but the most important irregularity observed is the want of persistence or continuity in these beds. Along the eastern edge of this vast coal-field[1] the coal-beds are much more persistent. As a general rule, the south-eastern portion of a coal-bed is more persistent than the north-western, and the lower beds more so than the upper ones. This is one of the reasons why the coal is so abundant and can be found with so much certainty along the eastern outcrop of the lower beds, extending from Fort Gibson to Forts Smith and Scott, and thence across the Osage through Bates, Johnson, and Saline counties in Missouri, and through Boone, Howard, Randolph, and up the Chariton valley into Iowa. Everywhere along this line shafts can be sunk upon the lower coal-beds with an almost absolute cer-

[1] This coal-field occupies a large part of the Indian Territory south, all eastern Kansas, the north-western half of Missouri and southern Iowa, and south-eastern Nebraska. Its western boundary extends from a point west of Council Bluffs in an irregular line into Kansas, and thence through Manhattan and Emporium and south to the Verdigris and Fall River.

tainty of success. But farther west, and along the outcrop of the upper beds, mining operations for coal will be much more precarious.

The geologist can tell with certainty where the rocks containing each coal-bed can be found, and at about what depth; but this irregularity, or want of persistence, in the coal-beds renders it somewhat uncertain whether the coal will be found in its usual place.

But this slight variation from the usual characters in our coal-beds will not much diminish the vast quantity of coal in the State, or render them less important in an economical point of view.

As given in the section of the Coal-Measures, we have discovered twenty-two different beds, varying in thickness from a few inches to seven feet.

Beds of *Carbonate of Iron*, *Spathic Ore*, or *Kidney Ore*, are abundant in the middle and lower portions of this formation.

An examination of the section will show the position of the numerous beds of *hydraulic limestone* and fire-clays which have been discovered.

At one locality, on Mine Creek, a good show of galena was observed in the sandstones and shales of the Marais Des Cygnes Coal Series.

Lower Carboniferous.

The rocks of this formation consist of chert, cherty-conglomerate at the top, and coarse, gray limestones and hornstones below. They first come to the surface in a branch north of Baxter's Spring, and were next seen at Baxter's Spring and down the branch to Spring River. A thickness of 120 feet was exposed at these places.

This is the lead-bearing limestone of south-west Missouri. The extensive and rich mines at Granby, Centre Creek, and Turkey Creek, east of the State line, are in these rocks, and these deposits and veins of lead may be expected in Kansas as well as in Missouri.

These are the lowest and oldest rocks in the State. They occupy the surface over a small area only in the south-east, and then dip beneath the coal-measures in their extension to the north and west.

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[SECOND SERIES.]

Art. XXVIII.—*Some Remarks in regard to the Period of Elevation of those ranges of the Rocky Mountains, near the sources of the Missouri River and its Tributaries;* by Dr. F. V. Hayden.*

[Abstracted from Capt. Wm. F. Raynold's forthcoming Report and published by permission of the War Department.]

The object of the present article, is to show, as nearly as can be done from known geological data, the period of the elevation of a portion of the Rocky Mountains. My observations have been more especially confined to the ranges from which the Missouri and Yellow Stone Rivers, with their numerous tributaries take their rise, though I feel confident that principles which will apply to mountains occupying so large an area will also be applicable to the whole Rocky Mountain district. It will be impossible, at this time, to mention in detail all the facts in support of my statements, and therefore I shall assume that the reader has examined the previous papers of my associate, Mr. Meek, and myself. During the coming year I hope to prepare a series of articles for this Journal which will have a more or less direct bearing on the physical geography of this region and the influ-

* For most important information I would direct attention to Second Series of this Journal, Articles xiii, xxxix, vol. iii, 1847, Art. xxxiv, vol. xii, 1849, and Arts. xxiv, xxv, vol. xxii, 1856, by Prof. J. D. Dana, in which, it seems to me, will be found the most profound, far-reaching generalizations in regard to the physical geography and geology of the West and other portions of our country, which have ever been given to the public. The origin and character of those subterranean forces which have produced such important results in the West are fully discussed in those papers.

ences which gave to it, its present configuration. Some erroneous statements, growing out of our limited knowledge of the structure of these mountain chains, may be made, but these when known, will be corrected. Geology is a progressive science and even our best efforts are but approximations to truth rather than the truth itself.

The evidence seems to me to be clear that the great subterranean forces that elevated the western portion of our continent were called into operation toward the close of the Cretaceous epoch, and that the gradual quiet rising continued, without a general bursting of the earth's crust until after the accumulation of the Tertiary lignite deposits or at least the greater part of them; also that after the fracture of the surface commenced and those great crust movements began to display themselves, the whole country continued rising, or at least, though there may have been periods of subsidence or repose, there was a general upward tendency which has continued even up to our present period. I hope hereafter to illustrate the correctness of these statements by all the facts that have been obtained in my past explorations as well as by those I may secure in the future.

Let us, in the first place, examine some of the barometrical profiles across the country from the Mississippi river to the Pacific coast, constructed under the direction of the War Department. Previously, however, to this examination we may make the statement that west of long. 98° the surface of the country may be separated into two divisions, mountain and plain, and that a combination of the two compose the Rocky Mountain district. After leaving the Mississippi the intervening country westward to the upheaved ridges is an apparently level or undulating plain, with no disturbance of the strata of the underlying formations until we come in close proximity to some of the mountain elevations. Reaching the base of the elevated ridges which form the mountain crests, we at once commence a rugged and abrupt ascent.

If we look at the profile constructed by Gov. Stevens, from St. Paul, Minnesota, lat. 44° 58′ and lon. 92° 58′ to the Pacific coast we shall find that the starting point is 828 feet above the ocean level. Near Fort Union, at the junction of the waters of the Yellow Stone and Missouri, 670 miles westward, the height above the ocean level has increased to 2010 feet, or 1182 feet higher than St. Paul. We thus see that the average ascent of the country between these two points is not quite two feet to the mile. From Fort Union to the Valley of Dearborn river, just under the base of the elevated ridges of the principal eastern range, we find the distance to be 448 miles and the height above the ocean 2081 feet greater than that at Fort Union, or the average rate of ascent increased to nearly five feet per mile. Over

this vast extent of country, extends an almost limitless prairie, apparently level, with no forests or groves, with no timber except that which skirts the streams. There is in this great distance, a gradual increase in the inclination of the strata proportioned to the increase of the ascent, but no marked disturbance of the beds until we arrive in close proximity to the mountain elevations. There are a few local fractures of the earth's crust, caused by the elevation of the Bear's Paw, Little Rocky Mountain, &c., around which the sedimentary rocks are more or less disturbed, but all these lesser mountains are more or less remotely connected with the main chain. After passing the highest point of the principal range, along this line, which is near Cadotte's Pass, we commence our descent toward the Pacific very much as we ascended the eastern slope, but over a much more rugged route. We find a continued series of more or less parallel ridges of elevation until we approach the coast for a distance of from 400 to 600 miles. From Fort Walla Walla to the ocean however, the average descent is a little less than one foot to the mile.

Again, if we examine the profile constructed by Fremont, commencing at the mouth of the Kanzas river, we find that the initial point is 690 feet above the ocean. Proceeding westward, the average grade for the first three hundred miles is between four and five feet per mile. Thence to Fort Laramie the ascent, as stated by Fremont, is 8 feet to the mile, and from Fort Laramie to Hot Spring Gate although still passing over prairie country the average grade of ascent is given by the same explorer, as 45 feet per mile. Over this entire route, however, loaded wagons have been transported with ease. When we reach the foot of the mountains in this direction, the lofty elevated ridges seem to rise abruptly out of the prairie, averaging from one to six thousand feet in height above the surrounding country. From thence to the Pacific coast we pass over a continued series of elevations which taken in the aggregate seem to trend nearly northwest and southeast, but which when examined in detail, often present no definite direction or continuous line of fracture. This mountain region is composed of a series of these ridges forming a belt or zone, 400 to 800 miles in width from east to west, interspersed with beautiful valleys through which wind streams of clear water. So numerous are the profiles which have now been made across the continent by different explorers that it is hardly necessary to describe each one, since what we have already said indicates the object in view.

We have said that the western portion of our continent, especially if we look only at the easterly slope may very properly be divided into mountain and prairie. It is true that in Kansas and Iowa groves of timber of considerable size are seen, but they form rather the exception than the rule. Along the eastern slope

there is a belt of country 300 to 600 miles in width, where, for the most part the only timber to be seen, is a thin fringe bordering the streams. Even in the eastern portion of the main range, the timber is not luxuriant, like that so common along the coast of Oregon and California. The pine trees are seldom more than three feet in diameter.

Again, we may divide the mountains or elevated ridges which form the different ranges into two kinds; viz., those with long extended lines of fracture, with a granitic nucleus and a comparatively regular outline, and those which appear to be composed of a series of cones or peaks more or less intimately connected, exceedingly irregular in their outline and of eruptive origin. Of the first class, the Black Hills, Big Horn, Laramie and Wind River mountains are good examples, while the Wahsatch, Green River, Jeton ranges and many others west of the dividing crest might be cited as illustrations of the second class. From all the information within our reach we have inferred that after passing the eastern slope the mountain ranges of eruptive origin are far the most numerous. We also know from personal observation that the main range of the Rocky mountains and the subordinate ridges on either side, near the head waters of the two principal branches, the Yellow Stone and Missouri, are of similar origin and present similar rugged features.

We may now return to the Cretaceous period. In a previous paper in this Journal,* we remarked that there were no indications in the geological formations of that portion of the West over which we have traversed of long continued deep water deposits, until we pass up into the Cretaceous epoch. The lower portion of No. 1, or the Dakota group, which ushered in the Cretaceous epoch in this portion of the West, is composed of coarse sand, pebbles, &c., with ripple marks, oblique laminæ, and with other indications of shallow water and change of currents. The same characters are seen throughout the formation wherever it is exhibited. We also know from the numerous impressions of leaves, and some beds of impure lignite, that dry land could not have been far distant. But as we pass up through Nos. 2, 3 and 4, whatever changes of land may have occurred in the meantime, we think there were periods at least when the sea was of considerable depth and suffered a quiet deposition to go on. We infer this from the fine and homogeneous character of the sediments. Throughout No. 4 we have a fine plastic clay which continues up into No. 5, when a gradual change takes place from the introduction of yellowish ferruginous matter, and a slow increase of sandy sediments. Toward the middle of No. 5, the sand begins to predominate until the upper part becomes a

* Vol. xxxi, March, 1861.

coarse, ferruginous sandstone, with all the indications of shallow water deposits. We know also, from fragments of wood and impressions of leaves which have been found quite widely distributed in the upper part of No. 5, that dry land could not have been far away. We also infer from the character of the Molluscan remains that the great Cretaceous sea which had so long spread its vast waters over this region was becoming shallow, and that a new epoch was approaching. As we arise in No. 4, and pass up into No. 5, there is an evident increase in the number of Gasteropoda indicating shoal waters. We have already remarked their peculiar Tertiary aspect, which seemed to point directly to that epoch, showing that it was not far distant. We may now ask the cause of this apparent approach to land, as foreshadowed by the lithological as well as the palæontological characters of the Upper Cretaceous formation No. 5. We think that the facts indicate that during the deposition of this formation the western portion of the continent was slowly rising above the ocean level, the waters on the one side receding toward the Pacific, and on the other toward the Atlantic, introducing the great Tertiary epoch which had already been foretold in the Cretaceous. At the commencement of the Tertiary period, throughout the central portions of the continent, lakes, estuaries, &c., more or less salt, at length becoming brackish, and finally fresh water, existed, and a new flora and fauna were introduced. The subterranean expansive power which was quietly lifting up the country still continued, although no bursting of the earth's crust had commenced. These brackish water deposits which appear to mark the dawn of the Tertiary period in the West, are distributed quite widely over the central portions of the Rocky mountain district and then by a general subsidence or a vast increase of fresh water, the true lignite deposits spread themselves over large areas and probably covered much of the country, now occupied by the mountain ranges and were doubtless more or less intimately connected with the Tertiary beds on the Pacific coast. What barriers separated them from the Tertiary formations along the Pacific—it is impossible from our present limited knowledge of the geology of the intermediate region, to determine.

We have remarked that the probable period of the bursting of the earth's crust which resulted in the formation of those abrupt mountain crests or ridges, occurred somewhere near the close of the accumulation of the true lignite deposits. We believe this for the following reasons. Whenever we observe the lignite beds in the vicinity of the mountain ranges we find them more or less inclined, in the same direction with the older fossiliferous rocks, though, as a general rule, dipping at a smaller angle, because more remote from the axis of the disturbing power.

Of course, as the land was slowly elevated toward the surface of the waters, the newer Tertiary beds would be subjected to the erosive action of water first, and thus continuing downward, as the mass was slowly rising, until the granitic nucleus was exposed. The Tertiary rocks, being composed for the most part of loose, yielding material, sands, clays and lignites, would be worn away from the surface for some distance from the axis of elevation. Although the lignite Tertiary beds are developed in full force all along the base of the larger ranges of mountains, it is not unlikely that some of these ridges formed barriers or lofty shores to these great Tertiary lakes. It would seem as if this country during the Tertiary period was not unlike the Undine region of the north, so called by the geographer Nicollet on account of the great number of fresh water lakes distributed over that district.

Near the Black Hills these beds are worn away from the immediate base of the mountains and it is doubtful from any proofs that we can now obtain whether the Tertiary lake extended over the country at that time occupied by the Black Hills. West of this range, the lignite Tertiary beds incline from the western slope 5 to 10 degrees. All along the Big Horn mountains, the same features, only more strongly marked, are seen. These beds often lie quite high upon the slopes of the mountains conforming to the Cretaceous rocks and sometimes inclining at a high angle. Between the western extremity of the Big Horn range and the Sweet Water mountains on the North Platte they are more disturbed than at any other locality. The lignite Tertiary strata are nearly vertical and the hard layers of sandstone or limestone extend in long projecting lines across the country, while the intermediate yielding beds of clay, sand, and lignite, are smoothed and leveled by atmospheric agencies and clothed with a thick turf of grass. All along the Laramie range, from the Red Buttes to Deer Creek, until the lignite beds are concealed by the White River group, the same features are seen, though the strata incline less, being more remote from the anticlinal crest. On both sides of the Wind River mountains the same phenomena occur, and other examples might be cited pointing to the same conclusions, but enough has been said to show that it is probable that the lignite Tertiary beds partook of the same movements that have elevated the older fossiliferous rocks. We therefore infer that the fracture of the earth's crust in this portion of the West, by which the nucleus of the mountains was revealed, occurred near the time of the accumulation of the lignite deposits or at the close of that epoch.

Again, although there is not a strict unconformability between the true lignite beds and the Wind River group, the latter incline in the same direction only at a much smaller angle. Near

the source of Wind river, the Wind river group rests directly upon Cretaceous formation No. 2. At this point the Cretaceous rocks incline from 10° to 25° while the Wind river beds dip from 1° to 5°. As we ascend the valley of Wind river, towards its source, we pass, for a long distance, the steeply inclined Cretaceous and Jurassic rocks along the margins of the mountains on our left hand, while on our right, but a few hundred yards distant, the naked, almost vertical walls of the lower portion of the Wind river group are seen, the strata however seldom inclining more than one degree.

The same examples may be observed on the west side of the Wind River mountains, where the Wind River beds lie high upon the sides of the western slope in a very slightly inclined position and in some localities covering the very summit, showing clearly that even the dividing crest of the mountains was beneath the waters during the deposition of this group. Along the margins of both the Wind River and the Big Horn mountains these beds seem to have risen undisturbed or in a nearly horizontal condition. We have already expressed the opinion in a previous paper,* that the Wind River group was intermediate in age between the lignite Tertiary and the White River beds, and in point of time filled up a chronological chasm. We have inferred this from the fact that these beds seem to possess palæontological and lithological characters intermediate between the two. They contain casts of a species of *Vivipara* which is undistinguishable from *V. trochiformis* and fragments of a *Trionyx* apparently the same with that occurring in the lignite beds, also fragments of a *Testudo* which, so far as we can determine, is identical with the *T. Nebrascensis* of the White River beds. If we look also at the composition of the Wind River beds, we find that their light color, indurated arenaceous and argillaceous character, and their general appearance after erosion favors the correctness of the inference in regard to their intermediate position. From the facts before us in regard to this group, we conclude that even after the crust broke, the country continued slowly rising while the Wind River deposits were accumulating, and that the upper portions when not eroded away were elevated high upon the sides of the mountains in a nearly horizontal position.

Again, the White River beds hold a similar position with reference to the lignite formations as the Wind River group. They are seldom disturbed, and only in a few instances do they incline as much as 5°. They however occur high upon the mountain slopes along both sides of the Laramie range, showing that they partook of the gradual elevation of the country, after the crust was broken and the mountain district began to approach its present configuration. On the west side of the Black Hills,

* See this Journal, vol. xxxi, March, 1861.

where the White River beds probably began their origin, we find only the lower strata of this group, usually reposing directly upon Cretaceous rocks, though in a few localities upon lignite formations. But as we descend south and southwestward these lower beds disappear and more recent ones take their place, until they pass into the Pliocene sands of the Loup River group, and then in turn, still farther southward, are lost in the Loess or yellow marl deposits. We can only account for these phenomena on the supposition that this great Tertiary fresh water lake had its commencement in the White River valley, and as the Black Hills, and of course the whole Rocky Mountain district, arose slowly towards its present elevation, the waters gradually receded southward and southwestward, and then more recent beds continued to be accumulated, until this formation spread itself over the vast area which it now occupies. We thus think that, by means of these Cretaceous and Tertiary deposits of the West, we can yet trace step by step the progress of that grand development which has given the present geographical conformation to the West, and originated the fountains from which flow those mighty rivers which may well be called the commercial arteries of the American continent.

Another illustration of the gradual and long continued rise of the country may be found in the immense chasms or cañons which have been formed by the streams along the mountain sides. We can only account for them on the supposition that as the anticlinal crest was slowly emerging from the sea, the myriad sources of our great rivers were seeking their natural channels, and that these branches or tributaries began this erosive action long before the great thoroughfares, the valleys of the Mississippi and the Missouri, were marked out. The erosion would go on as the mountains continued slowly rising at an almost imperceptible rate, and in process of time the stupendous channels which everywhere meet us along the immediate sides of the mountains would be formed. If we examine the barometrical profiles, already referred to, we see at a glance that in traversing the country from the Mississippi to the foot of the mountains the ascent is very gradual, but increases as we approach the upheaved ridges. In an equal proportion will the rapidity and consequently the erosive power of the streams be increased so that we may readily account for those grand displays of the erosive action of water which occur so frequently along the mountain sides. Eastward from the mountains, beyond this immediate influence, the descent is so gradual that the Missouri flows quietly along over its yielding alluvial bed, transporting its sediments to the Gulf of Mexico.

That the progressive elevation of the country continued up to our present period or at least until near the time of the deposi-

tion of the most recent superficial deposits, we think we have evidence derived from the terraces, which are seen all along the streams. The elevation of these terraces increases as we approach the sources of the rivers, averaging from a few feet to 150 or 200 feet in height. This subject will be discussed more fully in a future article.

We conclude therefore that the barometrical profiles, constructed from explorations across our continent, and geological data, indicate a long continued quiet expansion of the earth's crust, commencing toward the close of the Cretaceous epoch and extending even to our present period; that near the close of the accumulation of the Tertiary lignite deposits the crust of the earth had reached its utmost tension, the long lines of fractures had commenced, and the anticlinal crests of the mountain ranges were marked out. In a previous paper in this Journal, we remarked that there is no unconformability in any of the fossiliferous sedimentary strata in the northwest, from the Potsdam sandstone to the summits of the true lignite Tertiary. We believe therefore that the elevated ridges which form the nuclei of the mountain ranges began to emerge above the surface of the surrounding country near the close of the Eocene period. We think also that the evidence is clear that there were periods of subsidence and repose, but the thought which we wish to illustrate is, that there was a slow, long continued, quiet, upward tendency which began near the close of the Cretaceous epoch and culminated in the present configuration of the western portion of our continent near the commencement of our present period.

Smithsonian Institution, Washington, D. C., Jan. 1st, 1862.

ART. XXIX.—*Contributions from the Sheffield Scientific School of Yale College**—II. *On the Chemical Constitution of the Wax of the Myrica cerifera;* by GIDEON E. MOORE, B.P.

THE fruit of the Myrica cerifera yields a wax which for many years has constituted, to a limited extent, an article of commerce in the United States under the names of Myrtle-wax, Candleberry wax and Bay-berry Tallow. It occurs abundantly as a white incrustation on the small globular nuts of the plant. To prepare it in a nearly pure state, the berries are enclosed in bags of coarse cloth and kept immersed in boiling water until the fused wax collects on the surface, it is then poured off into pans in which it solidifies on cooling—in this form and without further preparation it is brought into commerce. It is employed in its

* Communicated by Profs. Johnson and Brush.

pure state as a polish to diminish the friction between surfaces of wood moving in mutual contact, and in admixture with other fatty bodies as a substitute for bees-wax in the manufacture of candles. It is also used in polishing furniture and enjoys some popular repute as a remedial agent.

We are indebted for the first published account of this substance to Alexandre,* Surgeon, correspondent of M. de Mairan, who mentions a wax obtained in Louisiana from the fruit of a tree about the size of a cherry tree and resembling myrtle in appearance, which he states to have been employed by the colonists in the manufacture of candles. Mr. Alexandre likewise states that the water in which the berries have been boiled, when evaporated to the consistence of an extract, is a certain cure for the most violent cases of dysentery.

At a later period accounts of the tree or shrub were given by Marshal, Lepage-Duprat, and by Toscan, Librarian at the Museum of Natural History at Paris. The latter in a memoir in his work entitled *L'Ami de la Nature* gave a circumstantial description of the mode of collecting the wax in early colonial times.†

The traveller, Kalm, speaking of myrtle wax says "in the country where it grows they make excellent soap of it which washes linen perfectly white."

The first attempt to investigate the chemical composition of this substance was made by the Danish chemist, Dr. John,‡ in the early part of the present century. By treating the wax from the *M. cerifera* with boiling alcohol, this observer separated it into two portions. To the soluble portion he gave the name of

* Histoire de l'Academie, Ann. 1722 and 1725—pp. 11 and 39.

† "Towards the end of autumn when the berries are ripe, a man leaves his house, together with his family, to go to some island or bank near the sea shore where the wax trees grow in abundance. He carries with him vessels to boil the berries, and a hatchet to build a cottage where he may find shelter during his residence in this place, which is usually three or four weeks. While he cuts down trees his children gather the berries. A very fertile shrub will afford nearly seven pounds. When these are gathered the whole family employ themselves in procuring the wax. They throw a certain quantity of the berries into the kettle, and then pour a sufficient quantity of water on them so as to cover them to the depth of about half a foot. They then boil the whole, stirring the grains about and rubbing them against the sides of the vessel in order that the wax may more easily come off. In a short time it floats on the water like fat, and is collected with a spoon and strained through a course cloth to separate it from any impurities which might be mixed with it. When no more wax can be obtained they take the berries out with a skimmer and put others into the same water, but it must be entirely changed the second or third time, and in the meantime boiling water must be added as it evaporates in order to avoid retarding the operation. When a considerable quantity of wax has been obtained by this means, it is laid on a cloth to drain off the water with which it is still mixed. It is then melted a second time, and it is then formed into masses. Four pounds of berries yield about one of wax; that which is first obtained is generally yellow; but in later boilings it assumes a green color from the pellicle with which the kernel of the berry is covered."—*Translation in Nicholson's Journal*, vol. iv, p. 189.

‡ Chemische Untersuchungen, iii, 38.

cerin and to the insoluble that of *myricin,* from the specific and generic names of the plant. Subsequently discovering as he supposed two identical substances in bees-wax he conferred upon them the same names, which are even still in use.

In the year 1802 Mr. C. L. Cadet* gave an account of the myrtle berry and the mode of culture, with experiments on the solubility of the wax in various menstrua, and mentioned that it saponified readily with the alkalies.

A few months later, Dr. John Bostock† gave an accurate description of the physical properties of the wax, its comportment towards solvents and alkalies, and concluded by stating the affinity of myrtle wax to the fixed oils—at the same time giving it as his opinion that the vegetable waxes bear the same relation to the fixed oils of plants that the resins do to the essential oils, i. e., are derived from them by the process of oxydation.

Besides these early imperfect notices of the myrica wax, we have more recently, an elementary analysis by Lewy who found its composition as follows:‡

Carbon,	74·00
Hydrogen,	12·00
Oxygen,	14·00
	100·00

Chevreul also examined the myrica wax. According to him it is completely saponified by potash-lye and yields in the operation besides glycerine, stearic, margaric and oleic acids.§ As will appear in the sequel, this distinguished chemist must have operated on an adulterated specimen.

The wax employed in the following research was the commercial article as found in the drug stores of New Haven, and was collected in the vicinity of this place. To the kindness of Mr. E. W. Blake, Jr., I am indebted for a small specimen prepared by himself from berries gathered in Rhode Island, this enabled me to test the purity of the commercial wax. The latter though procured at different times from several sources, in no case appeared to have been adulterated, as shown by the uniform fusing point of the wax itself, and of the mixed fatty acids resulting from its saponification.

The wax, as existing in commerce, is of various shades of color, from greyish-yellow, nearly destitute of any other tint, to a rich deep green, due to chlorophyll; the odor is balsamic and slightly aromatic, much more powerful however in the dark than in the light colored varieties. These differences in appearance and odor are not connected with any material variation in the other physical properties, such as specific gravity and fusion point, which remain nearly constant throughout.

* Annales de Chimie, xliv, 140.
† Nicholson's Journal, iv, 130.
‡ Handwörterbuch der Chemie, v, 413.
§ *Loc. cit.*

The specific gravity of myrtle-wax ranges from 1·004 to 1·006 and the point of fusion from 47° to 49° C. Its hardness and brittleness are much greater than those of beeswax. According to Dr. Bostock one hundred parts by weight of boiling alcohol dissolve five parts of the wax, four-fifths being deposited on cooling and one-fifth remaining suspended in the fluid but gradually depositing after a few days, or it may be precipitated at once by the addition of water. Only four-fifths of the wax are dissolved by hot alcohol, the remainder being totally unacted on even by prolonged digestion with fresh quantities of the solvent. Boiling ether, according to the same author, dissolves more than one-quarter of its weight of the wax, of which, the greater part separates on cooling. At a moderate heat it is also taken up by oil of turpentine to the extent of six per cent.

With a solution of caustic potash, myrtle wax saponifies readily, giving a fragrant soap which is freely soluble in water and which by decomposition with sulphuric acid yields a mixture of fatty acids fusing at 61° C., and readily soluble in hot alcohol. From this solution it may be wholly precipitated by an alcoholic solution of acetate of lead. Upon washing and drying the precipitate, and digesting it for several days at a moderate temperature with twice its bulk of ether, a waxy substance was dissolved which did not blacken by sulphid of ammonium and left no residue upon ignition, thus proving the absence of oleic acid. The portion dissolved by ether consisted of unsaponified wax which being suspended in the solution of soap in a state of fine division escaped detection, was carried down mechanically in the precipitate produced by acids, thrown down a second time in the precipitate by acetate of lead and was afterwards dissolved out by the ether.

A portion of the wax was saponified with litharge and the lead soap repeatedly washed with water. Upon evaporation of the washings in vacuo, a viscid fluid was obtained possessing the sweet taste and other characteristic properties of glycerine, the quantity obtained was, however, quite small in proportion to the amount of wax employed.

About two pounds of the wax were then saponified with caustic potash and the soap decomposed by sulphuric acid, the precipitate was fused and agitated repeatedly in contact with renewed portions of distilled water and finally dried. It possessed a fusing point of 60° C. A portion of this substance was introduced with a considerable quantity of distilled water into a capacious retort and subjected to distillation; after about one-half of the water in the retort had passed over, the distillate was found to contain a few globules of fused fat floating on its surface—these were collected and their fusing point taken—it was found to be identical with that of the substance previous to distillation,

thus proving conclusively the absence of the more volatile fatty acids.

One hundred grammes were taken, and after solution in alcohol, were subjected to fractional precipitation, the method originally proposed by Heintz* being employed under the following modification. The alcoholic solution of the fatty acids was made of such strength that the degree of saturation at which a precipitate separated on cooling to the ordinary temperature of the atmosphere, was almost, but not quite attained. The solution was measured and one-tenth part was poured into another vessel, this portion was then precipitated as accurately as possible by a saturated alcoholic solution of acetate of lead. The precipitate together with the fluid in which it was suspended was now poured back into the remaining portion of the solution, and the whole heated to ebullition and maintained at that temperature until the precipitated lead salt was redissolved and the fluid was brought to nine-tenths of its original bulk. The whole was then set aside to cool, by which the precipitate was a second time thrown down. This precipitate was collected on a filter and dried, as the *first fraction*. A portion of the filtrate equal to that first taken was now precipitated accurately with acetate of lead, the precipitate with the fluid in which it was suspended was poured back into the rest of the solution, the whole heated and evaporated until brought to eight-tenths of its original bulk, and after cooling, the precipitate collected and dried as the *second fraction*. This operation was repeated until *nine fractions* in all had been obtained, the fluid to be precipitated occupying successively, $\frac{9}{10}$, $\frac{8}{10}$, $\frac{7}{10}$, $\frac{6}{10}$, $\frac{5}{10}$, $\frac{4}{10}$, $\frac{3}{10}$, $\frac{2}{10}$, and $\frac{1}{10}$, of its original bulk. The last portion of fluid containing the *tenth fraction* gave no precipitate with acetate of lead, and upon examination was found to contain the ethylic ethers of the fatty acids with but very little free acids.

Of the fractional precipitates thus obtained, the 1st, 2d, 3d, 7th, and 9th were further examined. They were decomposed by repeated boiling with moderately dilute hydrochloric acid and the fatty acids thus separated were thoroughly washed by hot water. The fusing points of these products were as follows, respectively:

1st fraction, 60·5° C., 2d, 61·°, 3d, 61·°, 7th, 55·°, 9th, 50.° . The 10th fraction which gave no precipitate with acetate of lead remained fluid at 20·° C.

The fact that by long boiling the mixed fatty acids with water, a distillate was obtained which had the same fusing point as the original mixture, together with the narrow range of fusing points among the fractions first examined, made it appear unnecessary to study the others.

* Jour. für Prakt. Chem., lxvi, 1.

The products obtained from each of the above mentioned lead precipitates were severally subjected to repeated crystallization from alcohol until the fusing point of the crystals stood unaltered by further treatment. From each fraction an acid was thus procured which fused at 62° C., and agreed in all respects with *palmitic acid.* The first three fractions consisted almost entirely of this substance and it was present in considerable quantity even in the ninth fraction.

The filtrates from the crystallization of the 7th and 9th fractions were then mixed and subjected to recrystallization. A crop of crystals thus obtained likewise fused at 62° C. The new filtrates were then mingled and crystallized again with the same results.

The concentrated mother liquors from which nearly all the palmitic acid had thus been separated, were now evaporated nearly to dryness, and the mass saponified to destroy the ethers formed by prolonged contact with alcohol. The soap was decomposed by acids, the precipitate dissolved in alcohol, the fluid evaporated until a slight crop of crystals formed on cooling; the fluid poured off from these was again evaporated until a deposit ensued on cooling, and this process was repeated until the crystals thus formed exhibited a constant fusing point, viz. 43° C. It thus appears that *lauric acid* is an ingredient of this wax. The 10th fraction which was fluid at ordinary temperatures was found by similar treatment to consist almost entirely of *lauric ether* formed by prolonged contact with alcohol.

About one pound of the crude fatty acids was repeatedly agitated with small quantities of boiling alcohol until the fusing point of the portion undissolved, remained constant at 62° C. The several alcoholic solutions thus obtained were then mixed and evaporated to the point at which crystals formed on cooling, the whole allowed to cool to the ordinary atmospheric temperature, the crystals thus formed removed, and the process repeated several times, by which means a still further portion of the least soluble substance was removed. The fluid filtered from the crystals was now treated with caustic potash and after addition of water the whole was heated until no more alcohol could be expelled. The precipitate obtained by treating this solution with sulphuric acid, was dissolved in alcohol and subjected to a fractional crystallization to remove palmitic acid, by which means a sufficient quantity of the substance fusing at 43° C. was obtained for an elementary analysis.

The two substances thus obtained and which from their fusing points and other characteristic properties were pronounced to be respectively palmitic and lauric acids, were further purified by solution in alcohol, decolorization by animal charcoal, resaponification, decomposition of the soaps by acids, and careful washing

with distilled water, by which means they were obtained in a state of nearly absolute purity.

The above operations were very much complicated by the fact of the strong tendency of lauric acid to form an ether when left for any length of time in contact with alcohol. In this respect it far surpasses palmitic acid. A mixture of these two acids in which there was a great preponderance of the latter, was digested for several days in alcohol at the ordinary temperature of the atmosphere. Upon adding a weak solution of potash to remove uncombined acid, and finally washing with water—an oily fluid was obtained which became solid by a very slight decrease in temperature, and which upon examination turned out to consist of nearly pure laurate of oxyd of ethyl. This ether could only be decomposed by prolonged digestion at a moderate heat with a very concentrated solution of fixed caustic alkali.

The palmitic and lauric acids obtained in the preceding operations were subjected to combustion with oxyd of copper and oxygen gas, with the following results:

0·1967 grms. palmitic acid gave 0·54 grms. carbonic acid and 0·228 grms. water.

	Theory.		Experiment.
C_{32}, - - -	192	75·00	74·96
H_{32}, - -	32	12·50	12·87
O_4 - - -	32	12·50	....

0·1857 grms. lauric acid gave 0·4917 grms. carbonic acid and 0·202 grms. water.

	Theory.		Experiment.
C_{24}, - - -	144	72·00	72·21
H_{24}, - -	24	12·00	12·06
O_4 - - -	32	16·00	....

A portion of the crude wax was repeatedly treated with fresh quantities of boiling alcohol until no further solution ensued, the residue was several times crystallized from hot ether, and finally after decolorization with animal charcoal, maintained in a state of fusion for some time to remove volatile impurities derived from the ether. It possessed the fusing point, hardness, and other properties of pure *palmitin*. Since according to Bostock, boiling alcohol dissolves only four-fifths of the wax, the amount of palmitin present may be approximately stated at one-fifth of the whole.

The results of the foregoing experiments indicate that the wax of the Myrica cerifera consists of about *one-fifth* part of *palmitin*, the remaining *four-fifths* being free *palmitic acid* with a small quantity of *lauric acid*, the latter either free or in the state of *laurin*.

With regard to the uses of this substance, its composition and abundance suggest it to the chemist as the most convenient and accessible source of pure palmitin and palmitic acid, and it will

probably be the means of increasing in no small degree our knowledge of these bodies and their derivatives. As a substitute for bees-wax in the manufacture of candles, the Myrica wax appears to be worthy of more attention than it has yet received. In illuminating power it seems to be scarcely, if at all, inferior to the best bees-wax. It can be furnished at less than one-fourth of the cost of the latter material, and owing to its superior hardness it can be cast instead of having to be subjected to the tedious and expensive process of moulding by hand. By care in preparation, it can be obtained more free from color than crude bees-wax, and moreover, it is said to be rendered perfectly white by the ordinary modes of wax bleaching. It might probably be used also with advantage to harden paraffine candles.

Taking into consideration the abundance of the plant itself, its hardy habits of life—in fact it thrives best upon soils which from their poverty and proximity to the sea are unfitted for all other purposes of cultivation—the slight degree of attention required to insure abundant crops, and finally the ease of extraction of the wax itself, there appears to be no reason why the preparation of myrtle wax should not constitute an important branch of manufacturing industry.*

The foregoing investigation was undertaken at the suggestion of Prof. Johnson, for whose guidance and assistance I here take pleasure in expressing my grateful acknowledgments.

Sheffield Laboratory, New Haven, Feb. 3d, 1862.

Art. XXX.—*Considerations relating to the Quebec Group, and the Upper Copper-bearing Rocks of Lake Superior;* by Sir W. E. Logan, F.R.S., Director of the Geological Survey of Canada.†

(Read before the Montreal Natural History Society, May, 1861.)

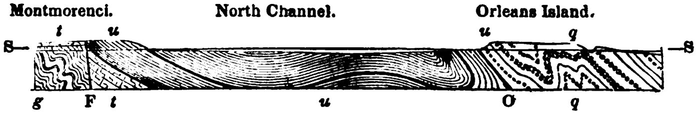
In a communication addressed by me to Mr. Barrande on the fauna of the Quebec group of rocks, (this Jour., xxxi, 216,) after showing that the organic remains discovered last year at Point Lévis, placed the group about the horizon of the Calciferous formation, I stated that the apparent conformable superposition of the group on the Hudson River formation was probably due to an overturn anticlinal fold or overlap.

* In course of the preceding investigation a property of the *palmitate of silver* was noticed which I believe has not yet been placed on record. I allude to its becoming powerfully electric by friction. A small quantity of this salt, purified from extraneous fatty matters by digestion in ether, was gently rubbed in an agate mortar, when a sufficient amount of electricity was generated to cause the powder to fly out in every direction and cluster around the pestle and the hand holding it.—G. E. M.

† From the Canadian Naturalist and Geologist.

The character of this overlap is exhibited in the accompanying wood cut (fig. 1) of a vertical section of the neighborhood

1.—*Section from Montmorenci to Orleans Island.*



Horizontal and vertical scale, 1 inch to a mile. *g*, **Laurentian gneiss;** *t*, **Trenton limestone;** *u*, **Utica and Hudson River formations;** *q*, **Quebec group; F, Fault; O, Overlap; S, Level of the Sea.**

of Quebec, extending from the Montmorenci side of the St. Lawrence across the north channel and the upper end of the Island of Orleans. The road from Beauport to Montmorenci runs over a floor of Trenton limestone, which has a very small dip towards the St. Lawrence; farther back from the river the rock has a gentle dip in an opposite direction, giving evidence of a very flat anticlinal form, which could scarcely be detected without the aid of the general distribution of the formations in the neighborhood. On the south side of the road there occurs a dislocation, which can be traced the whole way from Beauport church to Montmorenci falls, where the effect it produces is easily discernible. Here the channel of the Montmorenci is cut down through the black beds of the Trenton formation, to the Laurentian gneiss on which they rest, and the water at and below the bridge flows down and across the gneiss, and leaps at one bound to the foot of the precipice, which, immediately behind the water, is composed of this rock. At the summit, the Trenton beds are seen on each side; on the right bank they have a thickness of about fifty feet, and are marked by the occurrence of *Leptæna sericea* (Sowerby), *Strophomena alternata* (Conrad), *Orthis testudinaria* (Dalman), *Lingula crassa* (Hall), *Conularia Trentonensis* (Hall), *Calymene Blumenbachii* (Brongniart), and *Trinucleus concentricus* (Eaton). The dip of these beds is down the stream, at a very small angle; but at the foot of the precipice, and immediately in contact with the gneiss, about the same thickness of black limestone is tilted up to an angle of fifty-seven degrees. This is followed by about an equal amount of black bituminous shale with the same slope. In this attitude, these rocks climb up the face of the precipice, presenting their edges to the chasm on each side. They are succeeded by about eight feet of hard grey sandstone, weathering brown, in beds of from ten to eighteen inches, interstratified with black shale. On this repose grey arenaceo-argillaceous shales, composing the sides of the chasm out to the waters of the St. Lawrence; the distance being about a quarter of a mile, and the dip, which is towards

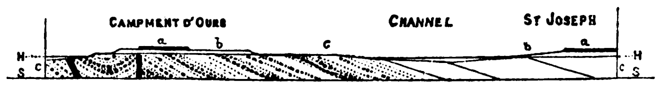
the St. Lawrence, diminishing gradually to about thirty-five degrees.

These tilted beds are fossiliferous, the species contained in the limestone being *Stenopora Petropolitana* (Pander), *Ptilodictya acuta* (Hall), *Strophomena alternata*, *Leptæna sericea*, *Orthis testudinaria*, *Camerella nucleus* (Hall), *Lingula* allied to *L. obtusa*, *Discina crassa* (Hall), *Bellerophon bilobatus* (Sowerby), *Conularia Trentonensis*, an undetermined *Orthoceras*, *Cyrtoceras constrictum* (Hall), *Calymene Blumenbachii*, *Cheirurus pleurexanthemus* (Green), *Trinucleus concentricus*, *Asaphus platycephalus* (Stokes). Those contained in the black shales are *Graptolithus bicornis* (Hall), and *G. pristis* (Hessinger). There is thus no doubt whatever that the limestones are of the Trenton and the shales of the Utica formation.

On the opposite side of the north channel, at the upper end of the Island of Orleans, there occur about 500 feet of black bituminous shales, interstratified with occasional beds of gray yellowish-weathering calcareous sandstone, and arenaceous limestone. They in some parts hold *Graptolithus bicornis* and *G. pristis*, and there is little doubt are subordinate to the Utica or Hudson River formation. They dip S.E. $< 50°$, and there rests upon them (the contact being visible) a series of magnesian shales and conglomerates, dipping in the same direction and at the same angle. These magnesian strata are of the same character as those at Point Lévis, and belong to the Quebec group. They thus overlap the black shales, which are probably overturned as represented in the diagram (fig. 1).

In his explorations of last year on Lakes Superior and Huron, Mr. Murray ascertained that the lowest well characterized fossiliferous rock in that neighborhood belongs to the Birdseye and Black River group, and that it rests conformably upon the sandstones of Sault Ste. Marie. These sandstones and their equivalents, consisting of red and yellowish-white beds, are traceable on the south side of Lake Superior, from Marquette to the River St. Marie, and compose Sugar Island, and probably the north part of Neebish Island. They extend to the north part of St. Joseph Island, and are met with on the Island of Camp-

2.



a, Birdseye and Black River limestone; *b*, Ste. Marie sandstone; *c*, Huronian conglomerates; H, Level of Lake Huron; S, Level of the Sea. Horizontal and vertical scale, 1 inch to 1 mile.

ment d'Ours. In one of the white beds near Marquette, Mr. Murray obtained a *Pleurotomaria* resembling *P. Laurentina* of the Calciferous formation, and observed the occurrence, in the

same bed, of a species of *Scolithus*. The mass on Campment d'Ours is of the same color and friable character as the yellowish-white beds near Marquette, and is marked by the same *Scolithus*, and there is little doubt that the two exposures are of the same series. On Campment d'Ours the sandstone reposes on the Huronian series, and is eighty feet thick and very nearly horizontal, (fig. 2). It is succeeded in ascending order, by the following series of beds:—

Bluish-gray shales, interstratified with thin beds of yellowish compact limestone, presenting an escarpment over the sandstone. The fossils observed are *Stenopora fibrosa*, *Ptilodictya fenestrata*, *P. acuta*, *Strophomena alternata*, *Rhynchonella plicifera*, and a small undetermined *Lingula*, - - - - - - - - - - - - - - -	20
Measures concealed, -	60
Ash-gray compact limestone, in beds of from three to five inches thick, interstratified with a five-inch bed of drab colored compact limestone. Among the fossils are *Stenopora fibrosa*, *Glyptocrinus ramulosus*, *Strophomena alternata*, *Pleurotomaria subconica*, *Subulites elongatus*, *Ambonychia amygdalina*, *Cyrtodonta Huronensis*, *Vanuxemia inconstans*, *Orthoceras tenuifilum*, *O. Murrayi*, *Leperditia Canadensis*, and *Asaphus platycephalus*, - - - - -	4
Ash-gray compact limestones, in beds of from four to six inches, underlaid by a dark brownish-gray arenaceous limestone bed of about ten inches, and divided by thin layers of gray calcareo-argillaceous shale. All of these strata are very fossiliferous, and contain *Glyptocrinus ramulosus*, *Ptilodictya multipora*, *Coscinium flabellatum*, *Strophomena alternata*, *S. filitexta*, *Rhynchonella recurvirostra*, *Orthis subequata*, *Vanuxemia inconstans*, *Cyrtodonta Huronensis*, *C. subcarinata*, *Pleurotomaria subconica*, *Trochonema umbilicata*, *Murchisonia perangulata*, *Orthoceras recticameratum*, *Cheirurus pleurexanthemus*, and *Leperditia Canadensis*, -	30
Ash-gray compact limestone, of the same character as the preceding, but still more fossiliferous. The beds contain *Tetradium fibratum*, *Stenopora fibrosa*, *Columnaria alveolata*, *Petraia profunda*, *Strophomena alternata*, *S. filitexta*, *Rhynchonella recurvirostra*, *Ambonychia amygdalina*, *Cyrtodonta Canadensis*, *C. Huronensis*, *C. mytiloidea*, *Vanuxemia inconstans*, *Ctenodonta nasuta*, *Pleurotomaria subconica*, *Eunema strigillata*, *Subulites elongatus*, *Orthoceras tenuifilum*, *O. Murrayi*, an undescribed *Cyrtoceras*, *Asaphus platycephalus*, and *Leperditia Canadensis*, - - - - - - - -	16
	130

The fossils of these limestones leave little doubt that they belong to the Birdseye and Black River group; and the underlying sandstones and other rocks, constituting the upper copper-bearing series of Lake Superior, may thus represent the Chazy, Calciferous, and Potsdam formations, and be equivalent to the Quebec group, with the black shales and limestones beneath it. This equivalency and the existence of an upthrow bringing the Quebec

group to the surface in the regions to the southeast, as already described in my letter to Mr. Barrande (this Journal, xxxi, 216) suggest the following considerations.

From the occurrence of wind-mark and ripple-mark on closely succeeding layers of the Potsdam sandstone, where it rests immediately upon the Laurentian series, we know that this arenaceous portion of the formation must have been deposited immediately contiguous to the coast of the ancient Silurian sea, where part of it was in some places exposed at the ebb of the tide. No want of conformity is known to exist between the Potsdam and Calciferous formations, and the Quebec group being of Calciferous age and 7000 feet thick, it follows that during the Potsdam period, while the sandstones of the formation were being deposited on a level with the surface of the sea, there must have existed a depth of at least 7000 feet of water over the area in which were subsequently deposited the strata of the Quebec group.

With the exception of a small mass of the Potsdam sandstone at St. Ambroise, we have no evidence of a marginal outcrop of this formation between the St. Maurice River and the Mingan Islands. No marginal outcrops of the Calciferous and Chazy formations have been observed from the longitude of Lake St. Peter to the same group of islands; and between the vicinity of Kingston and the north shore of Lake Huron, all three of these formations appear to be wanting. From the Mingan Islands to the Mohawk River in New York, the marginal outcrops of the Potsdam, Calciferous and Chazy united do not in any part much exceed 1000 feet in thickness; while the thickness of the Quebec group alone, is about 7000 feet. This, constituting the great metalliferous formation of the continent, is traceable, under various designations, from Gaspé to Alabama, thence sweeping round on the west side of the Mississippi, through Kansas, to Lake Superior, where it appears without any diminution in its volume.

From these facts, it would appear probable that, during the Potsdam period, the older rocks, which formed the coast of the Lower Silurian sea, extended, under comparatively shallow water, southeastwardly from the St. Lawrence and the Ottawa, to the fault which brings the Quebec group between Gaspé and the Mohawk; and southwestwardly from a line between the Mohawk and Lake Superior, as far as Alabama. All around this shallow area, they descended quickly into deep water; thus constituting a subaqueous promontory from the Laurentian and Huronian rocks of the north, and forming, with these, what Mr. James D. Dana has termed the nucleus of the North American continent.

But although the great volume of the Quebec and Potsdam groups, shows that over the area occupied by them, there must have existed a deep sea during the Potsdam period; it is to be

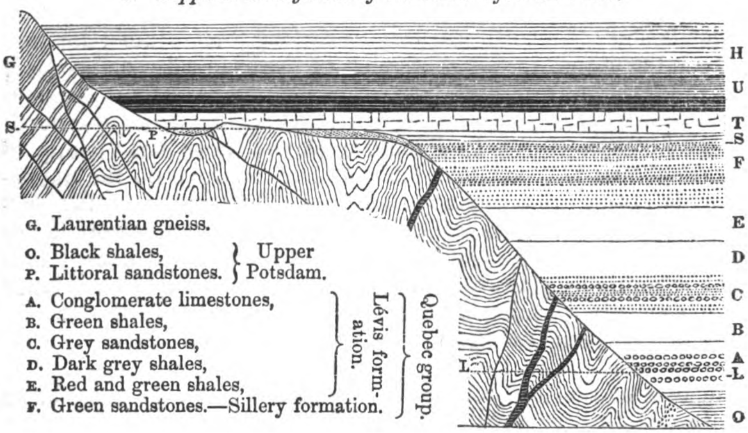
remarked, that many of the members, both of the lower and upper parts of the Quebec group, have by no means the characters of deep-sea deposits. It has already been stated, that the beds of passage between the littoral portions of the Potsdam and Calciferous formations, suggest the opinion, that, towards the termination of the Potsdam era, a gradual sinking of the surface had occurred. In order to obtain the conditions for the accumulation of the coarser sediments, which commence near the base of the Quebec group, it must be supposed, that, shortly after the beginning of the Calciferous period, a great continental elevation occurred; carrying the littoral deposits of the Potsdam, and the beds of passage just mentioned, high above the sea, and bringing the area at the base of the Quebec group comparatively near the surface. The successive coarse deposits of the group indicate a subsequent gradual subsidence, at unequal intervals, probably with subordinate oscillations, until the early shallow-water strata were again submerged; to be first partially covered over by deposits of the Chazy formation, and then, almost universally, by those of the Trenton and Hudson groups.

In this way may be explained the break which occurs in the succession of life between the Calciferous and Chazy, in the shallow-water deposits of these formations between the Allumettes Islands and Montreal, as well as among the Mingan Islands. The interruption in the succession of deposits between the base of the Trenton group and the Potsdam, at St. Ambroise; and that between the same base and the Laurentian, from the north shore of Lake Huron to Kingston, as well as in the vicinity of St. Paul and Murray Bays, and at Lake St. John on the Saguenay, is in the same way accounted for. The break in the succession of life between the Chazy and the Trenton group, is not so great as that between the Calciferous and the Chazy. It is not yet quite certain, that, at the marginal outcrop of the latter formations in Canada, a single species passes upwards into the Chazy; while about one-sixth of the species of the Chazy are known to occur in the Birdseye and Black River formation, at the base of the Trenton group. It seems to be in accordance with this, that we have evidence of a somewhat sudden submergence for the commencement of the Trenton period, and a somewhat rapid accumulation of its lower strata, the Birdseye and Black River limestones. Where these rest upon the Huronian and Laurentian series, the beds of contact are often composed of angular fragments of the underlying rock; and it frequently happens that the surface on which these beds rest, is rough, and broken into sharp projecting ledges and deep fissures, which were filled up and covered over by the deposits in question, before sufficient time had elapsed to permit the surface to be worn down. Instances in illustration of this occur on the Snake Islands, west of Lacloche, in Lake Huron, where the Birdseye

and Black River formation rests on the quartzites of the Huronian series; and at Marmora, where it is supported by Laurentian rocks. Dr. Dawson has pointed out a striking instance of these phenomena at Hog Lake in Huntingdon; other examples occur at Sloat's Lake in Loughborough and its vicinity, as well as at Kingston Mills. The same conditions may be observed in the neighborhood of Murray Bay.

As an instance of the probably rapid slope of the bottom of the Lower Silurian sea from shallow to deep water, during the Potsdam period, in the neighborhood of Quebec, we see that the surface of the quartzose gneiss now supporting the Trenton formation at the Falls of Montmorenci, must have been 7000 feet above the gneiss under the island of Orleans; while the distance between the two positions does not much exceed a mile and a half. This would give a slope of nearly forty-five degrees; and perhaps it would not be extravagant to take this as representing the inclination along the whole line to Alabama. As the Potsdam and Quebec groups accumulated, the edges of their strata would abut against this slope; and ultimately both these, and the early shallow-water deposits on the higher terrace, would be

3. *Supposed arrangement of the strata before the break.*



T. Trenton group of limestones; U. Utica shales; H. Hudson River sandstones and shales; L. L. Sea level at the commencement of the Quebec period; S. S. Sea level at the close of the Potsdam, and also at the beginning of the Trenton period. Vertical scale of the section, one inch to a mile.

covered over by the Birdseye and Black River, the Trenton, the Utica, and Hudson River formations. This we have endeavored to represent in the accompanying ideal diagram; in which it will be perceived that the lowest of these formations is shown as resting (at P.) on one of those littoral deposits of Potsdam sandstone, like that at St. Ambroise, which are still met with along the marginal outcrop.

The strike of this rapid slope in the bottom of the ancient sea, coinciding with the break, had, as already indicated, a general northeastward bearing, from Lake Champlain to the vicinity of Cape Chatte. The present trend of the Laurentian gneiss, from the neighborhood of Quebec to Pointe des Monts, has a rude parallelism with it; but farther down the valley of the St. Lawrence, while the line of break turns gradually eastward, and ultimately south of east, in Gaspé, the trend of the gneiss becomes northward for about sixty miles, then eastward for three hundred miles, and finally northeastward for two hundred miles more, to the Atlantic extremity of the Straits of Belle Isle. This divergence of the two lines would lead us to anticipate an area of shallow water during the Lower Silurian period; so protected from disturbance that any strata occurring there, might be expected to present a comparatively horizontal attitude, like that of the Lower Silurian formations on the same side of the break to the west. We accordingly find, in the Mingan Islands, in Anticosti, and on the Straits of Belle Isle, the Lower Silurian deposits in such an attitude. In the latter locality, however, the volume of the undisturbed strata would appear to indicate that the bottom shelved more gradually before reaching the slope. The increase of the dip in approaching Bonne Bay in Newfoundland, suggests that we may expect to find the break somewhere in that neighborhood.

Without enquiring into the origin of the forces which may have produced the corrugations of the earth's crust, we may suppose that if a sufficient lateral pressure were applied to the strata thus accumulated and arranged, there would result a series of parallel folds running in a direction at right angles to that of the force, with prevailing overturn dips towards the line of resistance. The solid crystalline gneiss in the case before us, offering more resistance than the newer strata, there resulted a break coinciding with the inclined plane at the junction of these with the gneiss. The lower palæozoic strata, pushed up this slope, would then raise and fracture the formations above, and be ultimately made to overlap the portion of these resting on the edge of the higher terrace; after probably thrusting over to an inverted dip, the broken edge of the upper formations. The shallow-water strata of the higher terrace, relieved from pressure by the break, would remain comparatively undisturbed; and thus the limit of the more corrugated area would coincide with the slope between the deep and shallow waters of the Potsdam period. The resistance offered by the buttress of gneiss would not only limit the main disturbance; but it would probably also guide or modify, in some degree, the whole series of parallel corrugations, and thus act as one of the causes giving a direction to the great Appalachian chain of mountains.

ART. XXXI.—*On the action of substances of the Sulphur and Phosphorus Groups on solutions of the metals;* by THEODORE PARKMAN. (Abridged from his Inaugural Dissertation, Göttingen.)

THE subject of the following dissertation was suggested by an observation made in the laboratory of Prof. Wöhler, at Göttingen. In precipitating selenium, by sulphurous acid, from a solution which contained considerable copper, the selenium obtained was black, although the precipitation took place in the cold. On investigation, the selenium was found to contain copper. My honored instructor, Prof. Wöhler, suggested to me that, as this reaction was a new and somewhat singular one, to extend it to tellurium, sulphur, phosphorus, arsenic and antimony, might afford the matter for a not uninteresting investigation.

I. *Action of Sulphur on the solutions of Copper, Silver and Lead.*

As just mentioned, precipitated selenium, placed in a solution of sulphate of copper containing sulphurous acid, unites with copper. I find that sulphur, tellurium, phosphorus, arsenic and antimony all do the same. In most cases also, the same effect is produced, especially with the aid of heat, without the presence of sulphurous acid or other reducing agent. I have also extended the investigation, though less completely, to the salts of silver and lead. With the exception of the action of phosphorus on the copper and silver solutions, all these reactions appear to have been previously undescribed.

1. *Action of sulphur without the aid of reducing agents.*—Precipitated sulphur and flowers of sulphur were left a week in solutions of sulphate, acetate and chlorid of copper. At the end of that time, they were entirely unchanged. Precipitated sulphur, boiled five or six hours with the sulphate, was slightly blackened, from formation of sulphid. Precipitated sulphur and flowers of sulphur, boiled with the acetate, rapidly blackened and were finally, apparently, entirely converted into sulphid of copper. Sulphur,* left three days in solution of nitrate of silver, became dark grey. Boiled in solution of nitrate of silver, it became rapidly black and seemed to be entirely converted into sulphid of silver. Sulphur, boiled with acetate of lead, only by very long boiling became dark grey.

2. *Action of sulphur with the aid of reducing agents.*—Sulphur, left for some hours in solutions of sulphate, acetate and chlorid of copper, with which sulphurous acid was mixed, became gradually dark grey, from formation of sulphid. Left a week in similar solutions, it appeared to be almost entirely converted into dark blue or black sulphid of copper. By boiling the solutions, the reaction took place much more rapidly, the sulphur becoming black in a few minutes. Sulphur, green vitriol and

* In all the following experiments the sulphur used was precipitated by sulphuric acid from hyposulphite of soda.

sulphate of copper, boiled together, gave sulphid of copper rapidly. Sulphur, zinc and sulphate of copper, boiled together, gave, along with reduced copper, black sulphid.

Sulphur, boiled with acetate of lead and acetate of the protoxyd of iron, became rapidly black and was apparently completely converted into sulphid. The resulting sulphid contained no iron.

3. *Analysis of the products of the foregoing reactions.*—In preparing the above substances for analysis, my great care was to continue the action long enough to be sure that all the sulphur was converted into sulphid. In those prepared by simply boiling the sulphur with the solution of the metal, the boiling was continued from five to eight hours, in every case with an excess of the metallic salt. In preparing the sulphids by the aid of sulphurous acid, the sulphur was placed in the solution of the metal, the whole heated, though not to boiling, and then saturated with sulphurous acid gas. The solution was then boiled, allowed to cool, again saturated with sulphurous acid, and left to stand a couple of days in a closed flask. In every case, on opening the flask, there was still an excess of the metallic salt and of sulphurous acid. To prevent oxydation, the substances, during washing, were kept covered with water, as much as possible, and dried in vacuo. In none of them could any free sulphur be seen by the aid of the lens. Of each substance two preparations were made, in order to see if the composition of the substance remained constant.

For analysis, the substances were all dissolved by digestion with fuming nitric acid, which, in nearly every case, dissolved them completely. without separation of sulphur. The analyses of the copper compounds were made, in some cases, by precipitating the oxyd of copper, at the boiling point, by caustic potash, and the sulphuric acid from the filtrate, after acidulation, by chlorid of barium. In other cases, separate portions of substance were taken for the copper and sulphur determinations. The silver compounds were all analyzed by precipitating, first the silver by chlorhydric acid, and then the sulphuric acid, from the filtrate, by chlorid of barium.

Sulphid of copper prepared by boiling sulphur with acetate of copper.

1st preparation. 0·6946 grm. substance gave 0·2817 oxyd of copper and 2·6436 sulphate of baryta.

2d preparation. 0·3255 grm. substance gave 0·1479 oxyd of copper and 1·2938 sulphate of baryta.

	I.	II.
Cu,	32·37	36·28
S,	52·27	54·56
	84·64	90·84

Sulphid of copper obtained by the aid of sulphurous acid.

1st preparation. I. 1·9560 grms. substance gave 1·3145 oxyd of copper.
II. 1·7321 grms. substance gave 1·1615 oxyd of copper.
III. 0·6727 grm. substance gave 2·0356 sulphate of baryta.

2d preparation. I. 1·8346 grms. substance gave 1·4830 oxyd of copper.*
II. 2·2385 grms. substance gave 5·4626 sulphate of baryta.

		I. III.	II.
1st prep.	Cu,	53·76	53·54
	S,	41·54	
		95·30	

			Calculated.	I. II. Found.
2d prep.	Cu,	31·7	66·46	64·54
	S,	16·	33·54	33·51
		47·7	100·00	98·05

Sulphid of silver prepared by boiling sulphur with nitrate of silver.

1st preparation. I. 2·0266 grms. substance gave 1·6800 chlorid of silver and 4·9156 sulphate of baryta.
II. 1·3725 grms. substance gave 1·1359 chlorid of silver and 3·2839 sulphate of baryta.

2d preparation. 0·4670 grm. substance gave 0·3519 chlorid of silver and 1·4593 sulphate of baryta.

		I.	II.
1st prep.	Ag,	62·39	62·28
	S,	33·31	32·86
		95·70	95·14

			Calculated.	Found.
2d prep.	Ag,	108	57·45	56·70
	5S,	80	42·55	42·91
		188	100·00	99·61

The formula CuS, derived from one of the above analyses is probable enough. The formula AgS^5 is not a probable one, and the substance is perhaps a mixture of the ordinary sulphid of silver with unchanged sulphur. No sulphur, however, could be seen by the aid of a lens. The substance was apparently a perfectly homogeneous, dark-grey powder. Lumps of it, when crushed, had the same appearance.

* According to Rose (Analytische Chemie, ii, 187) in igniting oxyd of copper, the filter may be burned along with the precipitate, and any suboxyd formed may be reoxydized by means of the current of air, which may be directed into the crucible by means of the cover. This is probably true in most cases, but sometimes there may be considerable loss through reduction. In the above analysis, after weighing once, I ignited and weighed again. The substance had increased considerably; and only after ignition, in a current of air, of three or four hours in all, and a total increase in weight, from the first weighing to the last, of 0·0568 grm. (=3·1 per cent of the substance analyzed) was a constant weight obtained. On breaking up the lumps of oxyd of copper, some red suboxyd still remained, which had been protected from oxydation by the coat of protoxyd on the outside. This would account, in part at any rate, for the percentage of copper in the above analysis coming out too low. It is decidedly advisable to burn the filter separately. This was done in my other analyses, with one exception, in which, from its close correspondence with another analysis, little or no loss appeared to have been incurred.

It will be seen that, in the analyses of the above substances, two preparations excepted, there is a large loss, if the substances be supposed to consist only of sulphur and metal. That this loss is not owing merely to incorrect analyses is shown by the pretty close correspondence of the analyses of the first preparation of sulphid of silver and of two of the copper determinations. I at first supposed that the sulphids had partly oxydized to sulphates: but, on heating them, first with water and then with dilute sulphuric acid, either none at all or only a trace was dissolved. Any sulphate, or other salt of silver or copper with the sulphur acids, should have dissolved up in the dilute acid. Heated in a dry test-tube, none of the substances gave any water. These facts led me to suppose that perhaps the presence of an oxysulphid, either alone, or mixed with a sulphid, might not be impossible. On examining the analyses in which there was a loss, I find that the analysis of one of the sulphids of copper corresponds closely to the formula $CuOS^3$.*

		Calculated.	Found.
Cu,	31·7	36·15	36·28
O,	8·	9·12	
3S,	48·	54·73	54·56
	88·7	100·00	

This formula is an improbable one, and I regret that I had not the time to investigate the subject further.

The analyses of the other sulphids did not correspond to any formula. When carefully examined under a lens, the copper compounds appeared to contain two substances. At first they appeared to be simply composed of a deep blue or blue-black powder. On breaking some of the lumps, however, these latter were found in many cases to be composed of a hard, light colored substance, with a reddish tinge and somewhat metallic appearance. Its appearance was very much like that of protosulphid of iron, which has been fused and then broken. The substance, which corresponded to the formula $CuOS^3$, was almost perfectly homogeneous and was different in color from the other copper compounds. It was dark grey, nearly black, without the bluish tinge of the others. The sulphids of silver were dark grey, one nearly black, the other considerably lighter. Both appeared to be perfectly homogeneous.

With regard to the manner in which the sulphids are forming by boiling sulphur with the salts of silver and copper, it might be supposed that one portion of the sulphur would be oxydized at the expense of the oxyd of the metal, while another portion of sulphur would unite with the metal thus set free. Whether this is the case or not, appears to be somewhat doubtful. After boiling sulphur a long time with solutions of acetate of copper and nitrate of silver, until the sulphur was well blackened, the filtrates were tested for sulphuric acid. In the copper solution none

* The oxysulphids already described are ZnO, ZnS, CoO, CoS, and MnO, MnS, described by Arfvedson (Pogg., 1), AsO^3S^2 by Bouquet and Cloez (N. Ann. de Chim. et Phys., 13, 14; J. der Pharm., 7, 23), and red antimony-ore, SbO^3, $2SbS^3$. Of all these, the only one, the composition of which bears much resemblance to the formula ($CuOS^3$), is the arsenic compound; and from the wide dissimilarity between arsenic and copper, this analogy is of but little value as a proof of the probability of the above formula.

was found; in the silver only a trace. Another portion of each filtrate was then tested for other acids of sulphur, by boiling with nitric acid and then adding chlorid of barium. No sulphur separated, on adding the acid, and chlorid of barium gave merely a trace of sulphate of baryta in the silver solution; none in the copper solution. It is possible that the sulphur may be oxydized to sulphurous acid. No smell of this could be detected, during boiling; but as the action of the sulphur is not very rapid, the sulphurous acid may have been given off in too small quantity to have been detected. Against this hypothesis, however, are the following considerations. As has been shown, sulphurous acid and other reducing agents greatly assist the formation of the sulphids, and this can be owing only to their reducing power. Now, if the sulphur be oxydized to sulphurous acid, some of this latter would be oxydized to sulphuric acid, of which, in the copper solution at least, not a trace could be detected. If the sulphur is not oxydized and no reducing agent be present, it would seem that one of two suppositions must be adopted: either the sulphur sets the oxygen of the oxyd free, which, I take it, is highly improbable, or the oxygen still remains in combination with the metal and an oxysulphid is formed. The substances no doubt vary with the circumstances under which they are formed—length of time in boiling, concentration of solution, &c.,—since two of the analyses made agree with the formulas of sulphids, without oxygen. One of these was formed with the aid of sulphuric acid. In the other, it may be supposed that the sulphur perhaps in this case acted as a reducing agent.

II. *Action of Sulphurous Acid on the Solutions of Copper.*

As sulphurous acid was used in forming several of the compounds above described, I deemed it advisable to make some investigation into the action of sulphurous acid alone on the solutions of copper used.

Sulphurous acid in most cases produces no effect on the compounds of copper with the stronger acids. Under certain circumstances, however, a solution of sulphate of copper gives with sulphurous acid a small quantity of the well known red sulphite of protoxyd and suboxyd of copper ($CuO, SO^2 + Cu^2O, SO^2 + HO$, Rammelsberg), and in other cases small crystals of metallic copper.*

The action of sulphurous acid upon acetate of copper does not appear to have yet been observed. I found that sulphurous acid gas passed through a solution of acetate of copper, heated, though not to boiling, gave at first a yellowish precipitate. This dissolved up again as the operation was continued, and the solution deposited a large quantity of small, bright red crystals. The reactions of these corresponded to those of the red sulphite, mentioned above. This gives, therefore, a new method of preparing the above salt.

The yellowish precipitate, just mentioned, may also be obtained by adding sulphurous acid water, in small quantity, to a solution of acetate of copper, which contains little or no free acid. After washing and drying it was of a yellow color, with a slight greenish tinge. It appeared to be entirely insoluble in water. No crystals could be detected by the lens.

* Wöhler, Ann. der Chem. u. Pharm., lxxix, 126–127.

With sulphuric acid it gave off sulphurous acid in large quantity. By solution of caustic potash it was converted into a bright green, insoluble substance.* By boiling with caustic potash, it gave black oxyd of copper. A portion, dried in vacuo, over sulphuric acid, gave off considerable water, on heating in a closed tube. It was found to contain no alkali, and no acetic acid.

For analysis, the salt was boiled with chlorine water until it dissolved, the sulphuric acid precipitated by chlorid of barium, the excess of chlorid of barium by sulphuric acid, and the oxyd of copper, at the boiling point, by caustic potash.

1·2266 grms. substance gave 1·0341 sulphate of baryta and 0·6975 oxyd of copper.

		Calculated.	Found.
2CuO,	79·4	57·37	56·86
SO^2,	32·	23·12	23·15
3HO,	27·	19·51	
	138·4	100·00	

The salt is very soluble in sulphurous acid, to a green solution. The latter, by standing, deposits the red sulphite. Acetic acid has a precisely similar effect. In preparing the salt, therefore, the solution of acetate of copper must be neutral and the sulphurous acid added in small quantity. If too much acid be added, the precipitate will be redissolved, even before the solution smells of sulphurous acid.

The salt appears to be hitherto undescribed. The only mention I can find of anything similar is in a paper on the sulphites, by Böttinger.

Böttinger,† by mixing a solution of sulphate of copper with sulphite of ammonia containing but a small quantity of free sulphurous acid, obtained a dirty greenish-yellow precipitate, which, on the addition of a little sulphurous acid, was rapidly and easily converted into a beautiful green liquid. This yellow precipitate he did not investigate further. I prepared a quantity of it for comparison with the salt which I obtained. The color of the two substances varied considerably from each other. That obtained by means of sulphite of ammonia was brownish-yellow, with little or no greenish tinge. That prepared from acetate of copper was of a much brighter yellow, with a decided tinge of green. Böttinger's salt, however, gave precisely the same reactions as mine. With strong acids it gave off sulphurous acid in large quantity. With caustic potash it became bright green. By boiling with caustic potash it became black and gave no smell of ammonia. The two salts, therefore, are no doubt identical.

III. *Action of Red Selenium on the solutions of Copper, Silver and Lead.*

1. *Without the presence of reducing agents.*—Red selenium, left four days in solutions of sulphate and acetate of copper, still remained red, showing that it had not combined with copper. The same, boiled with

* The green color was owing, probably, to the presence of a little hydrated suboxyd of copper, the yellow color of which, with the blue of the hydrated oxyd, would give green.

† Ann. der Chem. u. Pharm., li, 410.

sulphate of copper, for a long time, did not take up any copper. Boiled with acetate of copper, however, it was found to have united with considerable copper.

For analysis of the product of this last reaction, red selenium was boiled several hours with acetate of copper, thoroughly washed, and dried in vacuo. The substance obtained was a black powder, mixed with hard lumps, which, when broken, had a somewhat metallic lustre. For analysis, it was dissolved in nitric acid, the oxyd of copper precipitated, at the boiling point, by caustic potash, washed, dried, and ignited with saltpetre and carbonate of potash.

0·5237 grm. substance gave 0·0507 oxyd of copper.

		Equivalents.
Cu, - - -	7·73	1
Se (by difference),	92·27	9·7
	100·00	

Hence it would seem that the selenium was only partly converted into selenid of copper, notwithstanding that the boiling was kept up five hours, or more.

Red selenium, left four days in solution of nitrate of silver, gave a black powder, along with a few white flakes of (probably) selenious acid. After dissolving out the latter by means of caustic soda, the black powder was found to contain selenium and silver, both in large quantity. No free selenium could be seen in it, by the aid of the lens. (See remarks on the action of tellurium on nitrate of silver.)

Red selenium, boiled a long time with acetate of lead, took up no lead.

2. *With the aid of reducing agents.*—As already mentioned, red selenium, with sulphate of copper and sulphurous acid, becomes black, through formation of selenid of copper.

For analysis, a portion was prepared in the same manner as the corresponding sulphid of copper. The product obtained was a black powder, nearly homogeneous, but containing a few glistening particles, which looked like metallic copper. The substance was dissolved in nitric acid and the oxyd of copper precipitated as usual by caustic potash. The separation of copper and selenium in this manner is not quite perfect, a little selenious acid being usually precipitated, along with the oxyd of copper. Accordingly, the copper in the following analysis comes out somewhat too high.

2·0735 grms. substance gave 0·8336 oxyd of copper.

		Calculated.	Found.
2Cu,	63·4	61·61	62·00
Se,	39·5	38·39	
	102·9	100·00	

This same compound may also be formed by heating copper with selenium, or by igniting the protoselenid in a close vessel. (Berzelius.) It is also found native.

Red selenium, boiled half an hour with acetate of lead and acetate of the protoxyd of iron, did not take up any lead.

IV. *Action of Precipitated Tellurium on the solutions of Copper, Silver and Lead.*

1. *Without the aid of reducing agents.*—Precipitated tellurium, left four days in solutions of sulphate and acetate of copper, did not unite with any copper. Boiled with sulphate of copper, four or five hours, it also remained unchanged. Boiled with acetate of copper, it took up considerable copper. Some of the product of this action, obtained by boiling the tellurium four or five hours with the acetate, consisted of a black powder, containing a few glistening particles, otherwise homogeneous. An analysis of it was made as follows. The substance was dissolved in aqua regia and the oxyd of copper precipitated by caustic potash, dried, and ignited with nitre and carbonate of potash. To free the oxyd entirely from tellurous acid, it was again boiled with caustic potash. After weighing, the oxyd of copper was tested for tellurium and was still found to contain a trace.

0·2671 grm. substance gave 0·0831 oxyd of copper.

		Calculated.	Found.
2Cu,	63·4	24·82	24·82
3Te,	192·	75·18	
	255·4	100·00	

This and the following are, I believe, the only analyses that have been made of a tellurid of copper. Gmelin (Handbook of Chem. Engl. Transl.) merely mentions that tellurid of copper is pale red, according to Berzelius.

The action of tellurium upon nitrate of silver has been observed by Fischer: viz., that it acts very freely upon the solution of nitrate of silver, and forms a black powder, which does not assume the metallic lustre under pressure. Fischer does not mention whether the black powder was tellurid of silver or metallic silver, but leaves it to be inferred that it was the latter, as the observation is given in connection with the reducing action of the metals upon the salts of silver. That tellurid of silver is formed is probable from the analogous action of sulphur upon nitrate of silver, as well as of selenium and tellurium on acetate of copper. The following experiment also makes this probable. Precipitated tellurium was left four days in solution of nitrate of silver. At the end of that time, the solution still contained a large excess of silver. The black powder appeared under the lens to be perfectly homogeneous and to contain no white flakes of tellurous acid. It was found to contain silver and tellurium, both in large quantity. Now, if metallic silver was precipitated by the tellurium, probably little or no tellurium would remain unoxydized, after being in contact so long with an excess of the silver solution, but would either pass entirely into solution (the hydrate of tellurous acid dissolves in water with tolerable facility—Berzelius), or, if there was not enough liquid present to dissolve the whole, be visible as white tellurous acid.

Precipitated tellurium, boiled a long time with acetate of lead, precipitated no lead.

2. *With the aid of reducing agents.*—Precipitated tellurium, heated with sulphate of copper and sulphurous acid, united with considerable copper. For analysis of the product of this reaction, a portion was pre-

pared in the same manner as the corresponding sulphid of copper. The substance obtained was a black powder. It was ignited with nitre and carbonate of soda, and the oxyd of copper separated from the melted mass by dissolving in water. This method is not to be recommended. The platinum crucible used was attacked somewhat (perhaps because there was not enough nitre), and platinum was thus mixed with the oxyd of copper. To separate them, the oxyd of copper was ignited a long time, to bring all the platinum into the metallic state, and then dissolved out with nitric acid and precipitated by caustic potash. A better mode of analysis is that given in the analysis last described.

0·9498 grm. substance gave 0·3818 oxyd of copper.

		Calculated.	Found.
Cu,	31·7	33·12	32·09
Te,	64·	66·88	
	95·7	100·00	

Precipitated tellurium, boiled half an hour with acetate of lead and acetate of the protoxyd of iron, did not combine with any lead.

V. *Action of Phosphorus on the solutions of Copper, Silver and Lead.*

1. *Without the presence of reducing agents.*—The action of phosphorus on solutions of copper has already been observed by Bœck, Vogel and Bœttcher, and I have but little new to add to their observations.

Phosphorus, placed in a boiling solution of sulphate of copper, gave at first metallic copper, but this gradually blackened and by continued boiling appeared to be entirely converted into phosphid. This has been also observed by Böttcher. For analysis, I prepared some of the above phosphid by boiling phosphorus five or six hours with sulphate of copper. The substance obtained was a black powder, the larger particles possessing considerable lustre. Under the lens it appeared to be perfectly homogeneous. Even when finely pulverized, not a trace of metallic copper could be seen. Heated on platinum foil, here and there a very slight flame was observed for two or three seconds. The quantity of free phosphorus, however, if there was any present, must have been extremely small.

For analysis, a portion was dissolved in hydrochloric acid, with the aid of chlorate of potash, the solution heated until it no longer smelled of chlorine, diluted, and the copper precipitated by sulphuretted hydrogen. The filtrate was saturated with ammonia, and the phosphoric acid precipitated by sulphate of magnesia (mixed with chlorid of ammonium in sufficient quantity to prevent its precipitation by ammonia). The sulphid of copper was dissolved in fuming nitric acid and the oxyd precipitated by caustic potash.

0·6695 grm. substance gave 0·7301 oxyd of copper and 0·2916 phosphate of ammonia-magnesia.

		Calculated.	Found.
7Cu,	221·9	87·74	87·06
P,	31·	12·26	12·16
	252·9	100·00	99·22

The phosphids of copper previously described are Cu^6P, Cu^3P, and Cu^2P.

Phosphorus in solution of nitrate of silver throws down metallic silver, as observed by Bœck. The silver has the usual color and metallic lustre, and is apparently crystalline. No phosphid could be seen.

Phosphorus, left three days with a solution of acetate of lead in a closed test-tube, gave merely a few white flakes, probably of phosphate of lead. On boiling, a black precipitate was rapidly formed in large quantity, along with white phosphate of lead. After dissolving out the latter with caustic potash, the black substance was dissolved up in nitric acid, and tested for phosphoric acid. None was found: so that the substance, it would seem, was metallic lead.

2. *In the presence of reducing agents.*—Solution of sulphate of copper was saturated with sulphurous acid, phosphorus added, the whole heated somewhat, and left three days in a closed flask. On opening the flask, the solution was colorless. The result was metallic copper, and black phosphid of copper, along with unchanged phosphorus. I did not attempt to analyze the phosphid, as it was so intimately mixed with finely divided metallic copper that it was impossible to obtain it pure.

VI. *Action of Arsenic on the solutions of Copper, Silver and Lead.*

1. *Without the aid of reducing agents.*—Pulverized metallic arsenic, boiled with sulphate of copper, took up considerable copper. For analysis of the product of this reaction, pure metallic arsenic, pretty finely pulverized, was boiled several hours with concentrated solution of sulphate of copper. The substance obtained was a perfectly homogeneous, dark-grey powder. It was dissolved up in hydrochloric acid, with the aid of chlorate of potash, and digested at a very gentle heat with excess of chlorate of potash, in order to make sure of converting all the arsenic into arsenic acid, until the solution was nearly free from chlorine. The solution was then made strongly alkaline with ammonia and the arsenic acid precipitated by a mixture of sulphate of magnesia and chlorid of ammonium. This was washed with water, containing considerable ammonia, brought upon a weighed filter and dried at 100° C. From the filtrate, after acidulation, the copper was precipitated by sulphuretted hydrogen, dissolved in fuming nitric acid and reprecipitated by caustic potash.

1·0225 grms. gave 0·7211 arseniate of ammonia magnesia ($2MgO$, NH^4O, AsO^5, $+HO$) and 0·9276 oxyd of copper.

		Calculated.	Found.
6Cu,	190·2	71·72	72·43
As,	75·	28·28	27·83
	265·2	100·00	100·26

The arsenids of copper previously described are Cu^4As and Cu^3As.

Arsenic in solution of nitrate of silver throws down metallic silver, as already observed by Fischer.

2. *With the aid of reducing agents.*—Pulverized metallic arsenic, heated with solution of sulphate of copper and sulphurous acid, forms

arsenid of copper. For analysis, a portion was prepared in the same manner as the corresponding sulphid of copper. The substance obtained was a dark-grey, perfectly homogeneous powder. Two arsenic determinations were made, in the same way as in the last analysis.

I. 1·1215 grms. substance gave 1·4189
$2MgO, NH^4O, AsO^5+12HO$ (dried in vacuo).

II. 0·3235 grm. substance gave 0·2650
$2MgO, NH^4O, AsO^5+Ho$ (dried at 100° C.).

		Calculated.	Found.	
5Cu,	158·5	67·88	I.	II.
As,	75·	32·12	32·78	32·33
	233·5	100·00		

Pulverized arsenic, boiled half an hour with acetate of lead, precipitated no lead. With acetate of the protoxyd of iron and acetate of lead, it also produced no effect.

VII. *Action of Antimony on the solutions of Copper, Silver and Lead.*

1. *Without reducing agents.*—Pulverized antimony, left three days in solutions of sulphate and acetate of copper, took up considerable copper, in both cases. A little white oxyd of antimony was also formed. By boiling, the action takes place more rapidly, and a large quantity of the oxyd is formed.

As already observed by Fischer, antimony precipitates metallic silver from the nitrate. Towards the end of the action, some antimonid of silver is also formed, according to Fischer.

Antimony, boiled a long time with acetate of lead, produced no effect.

2. *With reducing agents.*—Pulverized antimony, left three days in solution of sulphate of copper, mixed with sulphurous acid, combined with considerable copper. No white oxyd could be seen. In acetate of copper the same effect was produced.

Antimony, boiled with acetate of the protoxyd of iron and acetate of lead, did not throw down any lead.

ART. XXXII.—*An Account of two Meteoric Fireballs, observed in the United States, Aug.* 2, *and Aug.* 6, 1860, *with computation of their paths;* by H. A. NEWTON, of Yale College.

I. *Meteor of Aug.* 2, 1860.

THIS magnificent fireball appeared about five minutes after ten, P. M., Cincinnati mean time, and was seen over the whole region from Pittsburg to New Orleans, and from Charleston to St. Louis, an area of nine hundred miles in extent. Through the kindness of friends, and from newspaper notices, I have been able to collect much information respecting it, the most important of which is presented in the following summary. I wish to express my indebtedness to Mr. Robert Brown, Jr., of Cincinnati, for valuable assistance. Materials which he had collected for his own use he has generously placed at my disposal.

1. *The path of the meteor through the atmosphere.*

Mr. Samuel Schooler, M.A., Principal of the Edge Hill School, Guiney's, Va., (N. lat. 37° 58′, W. lon. 77° 52′), saw it move North, its path being inclined downward at an angle of 10° with the horizon. At my request, he measured with a theodolite the place of first appearance, viz: S. 59½° W., alt. 7° 12′. It passed behind obstructions S. 70° W.

Prof. Evans, of Marietta College, Ohio, says: "B. K. Shaw, Esq., of Marietta, (lat. 39° 29′, lon. 81° 26′), saw the meteor pass near certain definite landmarks, such as tops of trees, chimneys, &c. It first appeared to him about 11° West of South, at an altitude of 8° or 9°. It was just emerging from behind a clump of trees. He saw it pass through the topmost branches of a tree 28° West of South, at an altitude of 6° or 7°. It disappeared behind a church, S. 43° W., at about the elevation of the eaves, that is, about 4° above the horizon. I took these angles with a theodolite as Mr. Shaw pointed them out with a ruler."

Rev. J. McD. Mathews, D.D., of the Hillsboro Female College, (N. lat. 39° 15′, W. lon. 83° 30′), says that a young lady saw first a bright light, then a ball of fire, which passed the window 60 feet from her, in range with the upper part of it. Its course was descending. The middle of the window was 20° or 25° W. of S. from her, and the middle of the upper panes 7½ feet higher than her eye, giving an altitude of 7° 8′.

Mr. Robert Brown, Jr., of Cincinnati, (N. lat. 39° 6′, W. lon. 84° 27′) gives S. 5° W., alt. 12°, for one point of its path.

Peraz R. Polley, Esq., of Ironton, Ohio, (N. lat. 38° 35′, W. lon. 82° 30′), says its altitude when first seen was 15°, and that it disappeared due S.W., at an altitude of 7°.

Prof. T. A. Wylie, D.D., of Bloomington, Ind., (N. lat. 39° 12′, W. lon. 86° 26′), says that by referring to the top of a house which was nearly in a line with the meteor, he is able to determine that the altitude of no part of the track could have exceeded 8°. The brightest light first caught his eye near S. 22° E.

Madison, Ind., (N. lat. 38° 45′, W. lon. 85° 18′). Seen S. 15° E. at half the elevation of the moon (25°). Disappeared S. 5° E.

At St. Louis, (N. lat. 38° 37′, W. lon. 90° 15′), its altitude when first seen in the S. E. was said to be 3°, and about half that at disappearance in the East.

Mr. F. C. Herrick, of Bowling Green, Ky., (N. lat. 37° 0′, W. lon. 86° 24′), sent me a diagram which makes its path horizontal, and passing under the moon at less than half the altitude of that body.

At Pitts Cross Roads, Tenn., (N. lat. 35° 40′, W. lon. 85° 10′), it was said to come from the moon's place in the heavens. Mrs. J. W. Redfield saw it, when it was a little East of North, apparently proceeding Northerly.

Nashville, Tenn., (N. lat. 36° 10′, W. lon. 86° 49′). Apparently it passed under the moon which was then S. 53° E., 26° high.

Rome, Tenn., (N. lat. 36° 14′, W. lon. 86° 6′); it came from the S.E., and moved N.E.

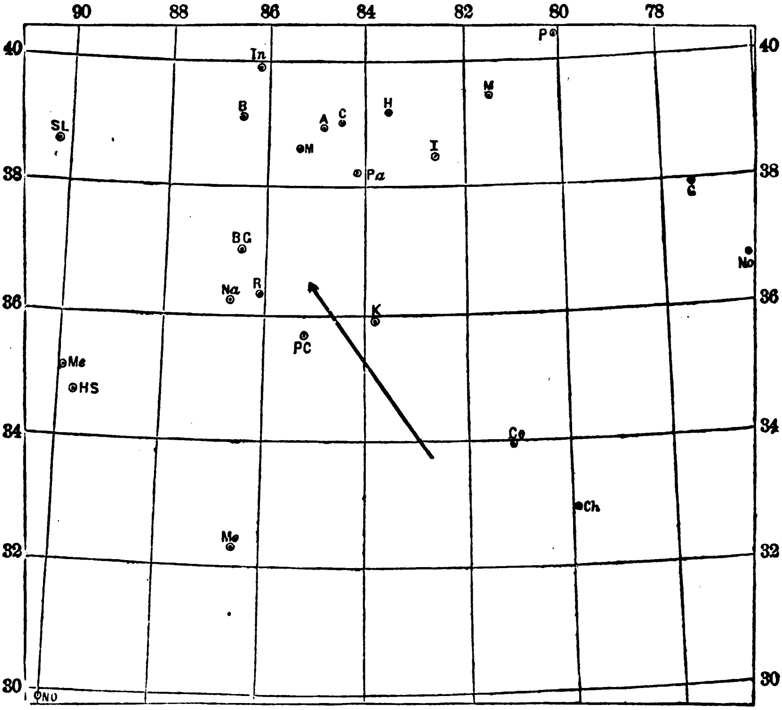
Montgomery, Ala., (N. lat. 32° 23′, W. lon. 86° 28′), started in the N.E. and went down almost due North.

Holly Springs, Miss., (N. lat. 34° 48′, W. lon. 89° 44′). Appeared in the Southeast, and exploded near the Northeast horizon. Greatest altitude 30°.

Charleston, S. C., (N. lat. 32° 46′, W. lon. 79° 56′), appeared nearly in the West at an altitude of about 40°. It did not disappear till very near the earth.

Many other indications of the path are given in the newspaper notices before me, but the estimates of altitudes are too great, or else the directions are manifestly in error.

1.



These observations indicate that the body first became visible over Northeastern Georgia about 82 miles above the earth's surface, near N. lat. 33° 50′, W. lon. 82° 40′, and that it exploded nearly over N. lat. 36° 40′, W. lon. 85° 5′, that is, over the south-

ern boundary line of Kentucky, at an altitude of 28 miles. The length of the visible path was about 240 miles, and its direction N. 35° W. The position of the places of observation, and of the meteor's path, are indicated in the chart, (fig. 1) in which the places are marked by their initial letters.

The following table affords the means of comparing the above observations with the computed path. In the third and fourth columns are given the azimuths and altitudes at which points of the line given above would be seen at the several stations. The altitudes are corrected for refraction. When the azimuths are those of the beginning or end of the assigned path, it is indicated in the 2d column. The altitudes in the last column are derived from the observations.

Place.		Azimuth.	Comp. alt.	Obs. alt.
Marietta, ...	Beg.	S. 11° W.	9° 00′	8° or 9°
"		S. 28 W.	6 40	6 or 7
"	End.	S. 48 W.	4 30	4
Guiney's, ...	Beg.	S. 47 W.	8 15	
"		S. 59½ W.	5 45	7 12′
"		S. 70 W.	3 30	5 25
Ironton, ...	Beg.	S. 2 W.	12	15
"	End.	S. 48 W.	6 45	7
Cincinnati, ...		S. 5 W.	8 25	12
Bloomington, ...	Beg.	S. 31 E.	8	not over 8°
"	End.	S. 22 E.	7 15	"
Madison, ...	Beg.	S. 23 E.	10 10	12 30
"	End.	S. 5 E.	10 15	12 30
Hillsboro, ...		S. 22 W.	7 10	7 8
St. Louis, ...	Beg.	S. 54 E.	5 15	3
"	End.	S. 66 E.	3 10	1 30
Charleston, ...	Beg.	N. 66 W.	24	40
"	End.	N. 47 W.	1 30	above horiz'n.
Nashville, ...	Beg.	S. 57 E.	14 30	
"	End.	N. 70 E.	15	
Pitts C. Roads, ...	Beg.	S. 48 E.	22 15	
"		S. 52 E.	24 3	27
"	End.	N. 4 E.	21 15	
Bowling Green, ...	Beg.	S. 45 E.	13 15	
"		S. 52 E.	15	12 30
"	End.	S. 72 E.	19 15	

2. *The duration of flight, and the velocity.*

Mr. Schooler, who is accustomed to the use of the transit instrument, gives six seconds. The estimate was made at the time. Mr. Shaw gives from five to seven seconds.

By others the following intervals were assigned. At Ironton, 2^s; Rome, 3^s; Charleston, 5^s or 6^s; Morrow, Ohio, 6^s or 7^s; Aurora, 10^s; Antioch Coll., 10^s; Pittsburg, 15^s; St. Louis, 15^s; Holly Springs, 15^s; Madison, 30^s; Cincinnati, Louisville and Nashville, several seconds; Chilicothe, nearly a minute.

These estimates lead me to consider 7 or 8 seconds as the most probable time of flight for the whole line. The corresponding

velocity is 30 or 35 miles a second. The heliocentric velocity is on this supposition 24 or 28 miles. The latter velocity would indicate a hyperbolic orbit. The least possible heliocentric velocity for a body describing the given line is about 15 miles a second.

3. *Sounds heard after the explosion.*

Dr. Jas. W. Redfield, at Pitts Cross Roads, writes, that about five minutes after its passage they heard a tremendous explosion, and immediately another not quite so loud, in the direction in which the meteor had proceeded. They were re-echoed in the opposite direction with the prolonged roar of thunder. To the ear the explosion was like the booming of distant cannon.

Dr. Alex. McCall, of Rome, says that five or ten minutes after its passage there came a hundred sounds, like cannon fired in a deep hole, or like a great bass drum pelted by some giant keeping time.

Mr. W. C. Kain, of Knoxville, says that three minutes after the meteor had vanished, a long, reverberating sound was heard, of at least a minute's duration.

Paris, Ky. It was said to have been followed by a dull heavy sound like thunder.

As Paris is 125 miles from the place of explosion, the source of the sound may however be questioned. The above are the only reliable accounts which I have seen from those who heard the explosion.

4. *Magnitude of the body.*

It is most natural to measure the apparent size of a meteor by the moon's disc. From such a comparison and the distance of the observer the diameter of the body is at once computed. But this gives, I am convinced, a result very wide of the truth. The estimate of size is always vague. Irradiation too seems to prevent the diminution of apparent diameter naturally due to increased distance. This appears by comparing the estimates of the size of the meteor of Aug. 2d, made at different distances from its path, as below. The numbers indicate the distances to the nearest point of the meteor's path.

Knoxville,	(50);	head much larger than Mars.
Pitts C. Roads,	(50);	large as the moon, second ball not as large.
Bowling Green,	(80);	at first large as Venus, grew to the size of the moon.
Columbia,	(120);	two feet in diameter.
Aurora,	(170);	nearly as large as the moon.
Cincinnati,	(175);	large as a barrel.
Bloomington,	(190);	greater than the moon.
Ironton,	(200);	large as a barrel.
Hillsboro,	(200);	large as the moon or larger.
Portsmouth,	(200);	larger than the moon.
Antioch Coll.,	(230);	equal to the moon.
Indianapolis,	(230);	at first large as a man's hand, grew to the size of the moon.
Enon, Ohio,	(235);	first like a shooting star, grew to the size of a cocoanut.

Holly Springs,	(270);	at first not much larger than Mars, grew to exceed the rising moon. Others said large as the moon, large as a barrel, and two feet in diameter.
Marietta,	(280);	nearly twice as large as the moon.
Memphis,	(290);	large as the moon.
St. Louis,	(310);	from one-half to the full size of the moon.
Pittsburg,	(385);	large as the moon.
Guineys,	(400);	at first large as a star of the 1st mag., but grew in size and brilliancy until the whole western part of the heavens was brilliantly illuminated.
Norfolk,	(415);	each part as large as a butter keg.

This table indicates that an increase of distance does not produce any decrease in the assigned size. In fact there is rather an opposite tendency. It is useless then to compute the diameter of a meteor's nucleus (or of the flame even, if it is flame that we see,) by comparing its visible diameter with that of a heavenly body, as the moon. Thus we may get in the present instance four miles, or half a mile, according as we use the more distant, or the nearer observations. For anything I can see the smaller of these diameters may be a hundred, or even a thousand times greater than that of the nucleus.

In several of the accounts mention is made of a regular, or an irregular increase in the apparent size of the meteor, and that too when the meteor was not approaching the observer. Such an increase, if true, must be due to increased brilliancy, and hence to irradiation, or else to a larger body of flame. In either case the larger diameter evidently does not belong to the meteoric body.

5. *Colors of the body and of the train.*

Some persons classify meteors according to color. Those seen by a single careful observer may perhaps admit of such an arrangement. But this classification seems of little use when the meteors are seen by different and unpracticed observers. The nuclei of the meteor of Aug. 2d were said to be, white—pearl—rose color—pale red—red—bright red—crimson—saffron—yellowish—greenish—bluish—blue. The corona and train were bluish—bluish white—blue—green—yellow—rose color—reddish—pale red—red—bright red—crimson—scarlet—dazzling white.

6. *Brilliancy.*

In brilliancy this must be ranked in the first class of meteors. Its train was not many degrees in length. The path of the meteor of July 20th, 1860, was longer, and its motion more deliberate and stately. Yet this exhibition was, I am convinced, in most respects more magnificent than that of its noted predecessor.

It did not leave the atmosphere—for its path was downward, inclined more than 10° to the horizon of the place of explo-

sion. It terminated abruptly, and that at a point low down in the atmosphere. It is impossible that it should have escaped again without a continuance of its visible path, and change of direction.

It must have been a solid body.—This is inferred; 1st, from the tremendous detonation that followed it; 2d, from its breaking up into several parts before disappearance; 3d, from visible explosions during the flight, during which multitudes of sparks were sent off; 4th, from its penetrating the atmosphere so far; 5th, from the similarity of the phenomena to those when aerolites are seen to come down.

Whether any parts of the body came to the ground except as fine dust it is impossible to say. Its tremendous velocity seems quite sufficient to entirely dissipate any substance.

I think it probable that only those meteors whose relative velocities are quite slow furnish aerolites. Those whose relative velocities are large are burnt up, or dissipated, before reaching the ground.

II. *Meteor of Aug.* 6, 1860.

On the evening of Aug. 6th, 1860, at about 7^h 38^m New York mean time, a very bright fireball was visible even in the strong twilight, from Pittsburg, Pa., to Roxbury, Mass. Its brilliancy was compared by several observers to that of Venus, and to that of Mars, which was then very bright in the southeast. To the nearer observers it was very much more brilliant than those planets. Near the middle of its course it appeared to distant observers to separate into two parts, while those who were nearer saw it continually giving off fragments. Had it appeared later in the evening it would perhaps have rivalled in brilliancy the displays of July 20th, and Aug. 2d. At Pittsburg and Buffalo the sun had gone down but 5^m before. No undoubted accounts of an audible explosion have been received.

Mr. Arthur N. Hollister saw the meteor from the roof of a house in New Haven (N. lat. 41° 18′, W. lon. 72° 55′). Two days afterwards I went with him to the place, and from his description of its path determined its places of appearance and disappearance to be, S. 80° W., alt. 6° to 7°, and N. 70° W., alt. 5°. To obtain the period of flight I requested him to suppose the meteor to pass again over the same arc of the heavens, with the same velocity as before, while the interval was noted by the watch. I cautioned him against making the motion too rapid. Three or four trials gave a result of 8 seconds. Another person who was with him gave 5 seconds for the interval, but 7 or 8 seconds was considered the more probable time of flight.

Mr. Homer G. Newton, the brother of the writer, saw the meteor from Sherburne, N. Y. (N. lat. 42° 41′, W. lon. 75° 33′).

and observed carefully its path with a view to future measurements. On the evening of Aug. 11th I went with him to the place of observation, and he described the track of the meteor which I recorded by referring it to stars then visible. A few days later I measured with a quadrant and compass the altitudes and azimuths as pointed out by him. The first measurements gave for the points of appearance and disappearance S. 59° W., alt. 11½°, and N. 84½° W., alt. 9¼°; the second gave S. 54½° W., alt. 12° to 12½°, and N. 84° W., alt. 9° to 9½°.

The period of flight, determined as in the New Haven observation, was in several distinct trials given always as 6 seconds.

Washington McClintock, Esq., saw the meteor from Pittsburg, Pa. (N. lat. 40° 32′, W. lon. 80° 2′). It passed across an open space between trees two or three hundred feet distant. His son, then a member of the Senior Class in Yale College, was called, but not in time to see it. The apparent path was immediately located as accurately as possible with reference to the trees. Measurements made some months later gave S. 82½ E., alt. 10¾°, and N. 39° E., alt. 11½° for the places of its emergence and disappearance behind the trees.

Mr. William Wheeler saw the meteor from Crum Elbow Point (N. lat. 41° 45′, W. lon. 73° 56′), on the east bank of the Hudson river, five miles above Poughkeepsie. When first seen it was 6° to 10° above the horizon, S. 80° W., and it sailed slowly northwesterly, inclined gradually downward, and disappeared behind the high hills about N. 70° W. Time of flight, 8 to 10 seconds.

All these persons except Mr. McClintock are recent graduates of Yale College. I have felt that the four observations were worthy of more than ordinary confidence. United with a large number of newspaper and other accounts, they indicate that the following straight line is not far from the true path of the meteor both in direction and position: starting from a point 39 miles above the earth, nearly over the southern line of Pennsylvania (N. lat. 39° 35′, W. lon. 76° 45′), and passing N. 80° W. to a point 36 miles high, west or northwest of Buffalo. Its length is 225 to 250 miles, and its least height above the earth 35 miles.*

In the 3d column of the following table I give the altitudes at which this line would be seen at these four and at other places at the azimuths assigned. In the 4th column are corresponding observed altitudes, obtained from newspapers and other sources.

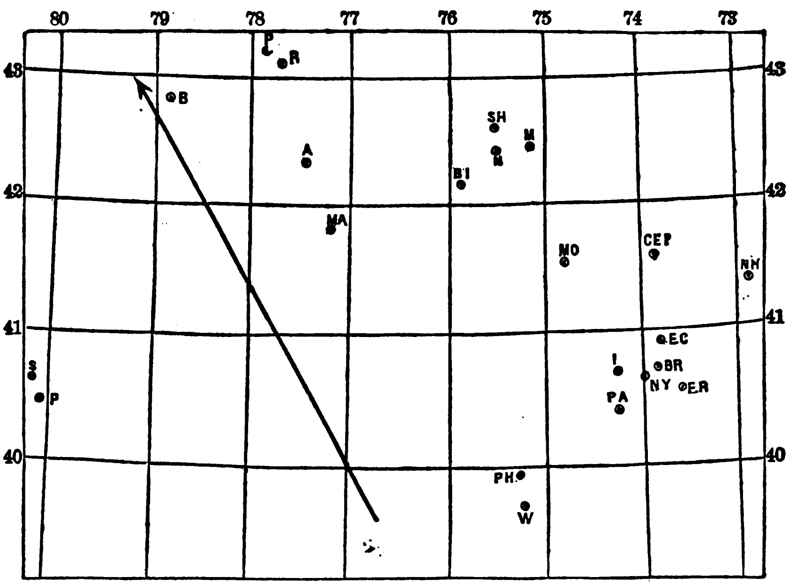
* Since this article was in type, Mr. R. T. Comstock of Westfield, N. Y. (N. lat. 42° 17′, W. lon. 79° 37′) writes to me that it passed 30° N. of the zenith of that place. As it disappeared at Buffalo towards the setting sun, the place of extinction is probably nearer N. lat. 43°, W. lon. 80°, than is represented in the chart. I have not however thought best to change the text. This change of path renders a hyperbolic orbit more probable.

When the azimuth has not been mentioned, I have assumed that that of the greatest altitude was meant.

Place.	Azimuth.	Comp. alt.	Obs. alt.	Place.	Azimuth.	Comp. alt.	Obs. alt.
	°	° ′	°		°	° ′	°
New Haven, ..	S. 80 W.	7 5	6	Philadelphia,	S. 85 W.	22 10	12¼
"	N. 70 W.	3 35	5	"	N. 52 W.	8 30	6½
Sherburne, ...	S. 57 W.	11 10	12	"	West.	21	25
"	N. 84 W.	9 40	9½	"	N. 70 W.	15 30	20
Pittsburg, ...	S. 82 E.	14 25	10¾	"	N. 40 W.	5	9
"	N. 39 E.	14 15	11½	Woodbury, .	West.	22 45	40
Crum Elbow Pt.,	S. 80 W.	8 30	6 to 10	Norwich, ..		12 15	10 or 15
"	N. 70 W.	5 15		Binghamton,	S.W.	17 15	20
Far Rockaway,	West.	8 30	15	"	N. 70 W.	10 30	12
Brooklyn, ...	S. 75 W	11 15	10	Avoca, ...		31	40
New York, ...		12 15	20	Mansfield, ..		35	40
East Chester, ..	West.	8 30	20	Rochester, ..		25 45	45
Irvington, ...		13 20	14½	Parma, ...		26 30	30
Perth Amboy, .	West.	11 30	30	Sewickley, ..		15	35

The positions of these places are indicated in the following chart (fig. 2) by their initial letters.

2.



The duration of flight and the velocity.

Mr. Wheeler gives eight or ten seconds for the passage of the meteor over 180 miles of its course. This gives a velocity of about 20^m a second.

The Sherburne observation gives six seconds for 115 miles, or 19^m a second.

Mr. Hollister gives 7 or 8 seconds for 215 miles, or 29^m a second.

Mr. Pratt of Binghamton saw the meteor for a course of about 190 miles. He rose from his seat and walked across the street during its flight to avoid losing sight of it behind buildings. Eight or ten weeks later he walked over the same space with what he considered the same speed, while I noted the interval, 15 seconds. Had this been done immediately after seeing the meteor it would have afforded by far the best determination of the time of flight. But a person under excitement must move more quickly than he would weeks afterward suppose. An interval of 15 seconds gives a velocity of nearly 13 miles.

Mr. Crowel who saw it from Sherburne gave 8 seconds as the interval of flight. Mr. Arthur G. Newton who saw it from Parma, N. Y., gave 6 seconds. The same method of obtaining the time was employed in both cases as in the New Haven observation. In the newspaper notices the following periods were assigned: at Roxbury, Mass., 10 or 15^s; Sharon, Ct., 15^s to 20^s; New York City, 5^s; Perth Amboy, 30^s to 45^s; Brooklyn 10^s to 15^s; Ironton, N. J., 10^s to 15^s; Morris, N. Y., 12^s; Riverdale, 30^s; Mansfield, 70^s; Avoca, 15^s; Evensburg, 8^s to 10^s; Danville, 40^s; Monticello, 30^s to 45^s; Rochester, 12^s.

I give all of the times assigned. But it is evident that the longer periods ought to be rejected. Disregarding those of 30 or more than 30 seconds, the average of the remainder is 11 seconds. Assuming that the observers saw the meteor describe on the average three fourths of its visible trajectory we have a velocity of 16 miles a second. But if we reject also the Sharon and Avoca observations, we have a velocity of 19 miles.

Unless there is a constant error in the method made use of at New Haven and Sherburne for ascertaining the interval of flight, eighteen miles a second must be considered a tolerable approximation to the true geocentric velocity. It is worthy of remark that the observers were in very favorable positions for estimating the time, the motion across the sky being quite uniform.

To obtain the heliocentric velocity it may be well to allow for the effect of the earth's attraction even though the amount of the correction is decidedly less than the probable errors of the observation, and are perhaps less than the effects of the resistance of the atmosphere. The increment of velocity due to the earth's attraction is $1^m{\cdot}4$ and the change of direction nearly 5°. These corrections applied to the direction and velocity above given would make the velocity $16^m{\cdot}6$ a second, towards R. A. 108° 30′, Dec. +43° 45′. The parts of the earth directly under the meteor were moving towards R. A. 42° 7′, Dec. +16° 15′. The heliocentric velocity of the meteor is then $30^m{\cdot}4$, towards R. A. 67° 45′, Dec. +33° 25′.

This of itself indicates a hyperbolic orbit.—Let us therefore inquire whether any changes are admissible that will make the

orbit an ellipse. The path of the meteor cannot be carried much to the eastward so as to shorten its length, and thus diminish the velocity. Its azimuth may be changed, several degrees even, without great violence to the observations, but this will have little effect upon the heliocentric velocity.

The meteor cannot reasonably be supposed to have ascended during the larger part of its course. On the other hand, to change it so as to make it describe a descending line would increase the heliocentric velocity.

Any change then must be in the duration of the flight. If the body was moving about the sun in an elliptic orbit, and the line given above was its true path, the geocentric velocity could not be greater than about 14 miles a second, which would require 16 or 18 seconds for the whole flight. This would moreover make no allowance for the resistance of the atmosphere. Though an elliptic orbit is very possible I can hardly think it probable.

Yale College, March, 1862.

Art. XXXIII.—*On Orthite from Swampscot, Mass.;* by David M. Balch, B.S.

More than a year since, while examining the rocks at Swampscot Beach, near the Clifton House, I observed a mineral occurring in small amorphous masses in quartz and red feldspar, which immediately attracted my attention by its peculiar lustre and appearance; this on examination has proved to be orthite almost identical with that from the Norway granite.

The shore at Swampscot and for half a mile or so N.E. towards Marblehead, consists of ledges of rock, against which the sea breaks, ranging from sienite to porphyry, and extending 50 or 60 feet backward, and, at the most, from 15 to 20 feet in height, to the pasture land above; these rocks are very rugged, seamed with trap, veins of quartz and red feldspar; in the latter occur good specimens of fibrous epidote, and the mineral furnishing the subject for this paper.

The orthite is found almost always imbedded in quartz, but I have obtained a few pieces from the feldspar, which forms the bulk of the veins; it occurs in black amorphous masses, sometimes surrounded with a reddish coating of sesquioxyds of iron and cerium, when much exposed to the weather or the action of the sea; and in very small quantity, for I only obtained a few grammes in return for searching the rocks throughout their whole extent. I examined this mineral shortly after its discovery, sufficiently to determine its name and general composition, and more carefully again this winter, and give below an outline of the method of analysis, and its results.

Zirconium, sulphate of zirconia,	White, insoluble in excess.
Aluminium, alum,	A white precipitate which redissolves in an excess of the precipitant.
Antimony, terchlorid,	A red brown precipitate insoluble in excess of precipitant.
Glucinum, sulphate of glucina,	A white precipitate insoluble in excess of precipitant.
Molybdenum, protochlorid,	No precipitate.
" bichlorid,	Reddish precipitate insoluble in excess of precipitant.
Palladium, protochlorid,	Abundant flesh-colored precipitate, insoluble in excess of precipitant.
Ruthenium, sesquichlorid,	Brown precipitate, insoluble in excess of precipitant.
Platinum, protochlorid,	No precipitate.

In describing the reactions of diethylamine I pointed out* that the remarkable property of dissolving alumina, hitherto considered as characteristic of ethylamine, amongst the ammonias, was shared by diethylamine. It now appears that it is possessed also by methylamine, and it would not be surprising if it was found to extend to the other methyl and ethyl bases, and even to the bases containing other alcohol radicals, a point which I propose hereafter to examine.

The deportment of methylamine towards solutions of protochlorid of molybdenum is characteristic, and differs from that of ammonia, ethylamine and diethylamine.

Methylamino-chlorid of Palladium.

When aqueous methylamine is added in excess to solution of protochlorid of palladium, or to a solution of the following salt, at the first moment no precipitation takes place, but in a few moments a quantity of flesh-colored needles are formed. These were dried over sulphuric acid and ignited.

·2049 substance gave metallic palladium ·0969.

From which we find:—

		Calculated.	Found.
2C,	12	9·32	
5H,	5	3·88	
N,	14	10·88	
Pd,	53·3	41·38	42·45
Cl,	35·5	27·56	
HO,	9	6·98	
	128·8	100·00	

leading to the formula $C_2H_5\widehat{N\,Pd}Cl+HO$.

* This Journal, Jan., 1862.

The palladium is a little in excess because with the small quantity of material at command, it was impossible to wash out the not entirely insoluble precipitate thoroughly, without too great a loss.

Chloro-palladite of Methylamine.

When methylamine is added, not in excess, to an acid solution of protochlorid of palladium, or when the foregoing salt is treated with an excess of the same acid solution, a deep brown red liquid is obtained, which by concentration yields beautiful brown red laminæ, very soluble in water and in alcohol. The quantity at command was insufficient for analysis, but judging from analogy, their constitution must be

$$C_2H_6NCl, PdCl.$$

Picrate of Methylamine.

This is a very beautiful salt. It crystallizes in bright yellow laminæ grouped in fine arborescent clusters, or by somewhat slower crystallization, in amber-colored bevelled prisms and hexagonal plates. Heated on platinum foil it deepens in color, melts to a clear red liquid apparently without decomposition, and when the heat is further raised, burns with a vivid white light leaving a carbonaceous residue. It is moderately soluble in water and in alcohol.

Other combinations of methylamine will be described at a future time.

ART. XXXVII.—*On Prof. J. Hall's claim of Priority in the determination of the Age of the Red Sandrock Series of Vermont;* by E. BILLINGS.

IN an article published in the last January number of this Journal (this vol., p. 107) Prof. Hall states that in 1844 and 1845 he made several sections from the Hudson river and Champlain valleys eastward, and that he then recognized the Potsdam sandstone at several localities both in Vermont and Massachusetts. It is very true that he did; but his paper is so written, that any person unacquainted with the facts would, upon reading it without due caution, understand him to mean that the rock which he identified as the Potsdam was the Red Sandrock Series. The object of this communication is to supply several facts not mentioned by Prof. Hall, and which if read in connection with his paper will throw some additional light upon the subject. Apart from all personal considerations, I hold that this investigation is

of such great importance that its history ought to be correctly worked out now while the facts are still fresh in the memory of all the parties concerned.

In order that what follows may be more clearly understood, it seems necessary to premise that the geologists of Vermont have always distinguished two great arenaceous formations in their country differing from each other in aspect and geographical position. One of these, the "Granular" Quartz Rock constitutes a narrow belt lying along the western base of the Green Mountains in the southern half of the state. In the recently published map of the Vermont Survey there are two outliers of this formation represented as occurring further north,—one in the county of Chittenden, completely surrounded by the formation now called the "Talcose" conglomerate, and another still further north lying alongside of the Georgia slate. This granular quartz rock is the formation recognized by Prof. Hall in his sections as the Potsdam sandstone, but it is not the formation always known under the designation of the Red Sandrock Series. This latter, and not the former, is the rock to which the papers of Mr. Hitchcock and myself relate. On the Vermont map and in Prof. Hall's sections, these two formations are indicated by different colors and distinguished by different names. Emmons considers the granular quartz rock to be an older deposit than the Potsdam. Prof. H. D. Rogers in 1840 examined it and came to the conclusion that it was the Potsdam itself.* The Red Sandrock Series forms an irregular belt along or near the shore of Lake Champlain, running the whole length of the lake and entering Canada near Phillipsburgh. The age of this rock has always been disputed, Dr. Emmons holding on one side that it was partly of the age of the Calciferous sandrock and partly Potsdam sandstone, while those who were opposed to his views on the Taconic System, held that it was a more recent formation. I believe it is now proved that Dr. Emmons' view is the correct one, and Prof. Hall's paper would lead us to suppose that he arrived at the same conclusion fifteen years ago. But the only documents that I can find which give us any clue to his original opinion are the sections to which he has made allusion, and the letter to Prof. Adams pointed out by Mr. Hitchcock. These do not prove that he agreed with Emmons, but rather that he was of a contrary opinion. The sections it appears were engraved but never published. I have however succeeded in procuring several of them and shall describe such portions as cross the Red Sandrock. By comparing Prof. Hall's paper it will be seen that he has omitted to make any allusion to these portions of the sections, the reason being, no doubt, that if he had done so, the reader would arrive

N. 1. Red Sandrock
No 2. Granular quartz rock

* See Proc. Am. Philosoph. Soc., vol. ii, p. 3, 1841, and also this Journal 1st ser. vol. xlvii, p. 151, where Prof. Rogers's views are given at length.

at a different conclusion from that intended to be induced by the learned Professor.

The first of these sections crosses Lake Champlain from Plattsburgh, traversing Hero Island and the towns of Milton and Fairfax. The only place where it crosses the Red Sandrock, is near St. Albans, and it must therefore pass through the Georgia slates very near the locality of the far-famed primordial trilobites. According to the new map of the Vermont Survey, above quoted, there is here a strip of Red Sandrock two miles wide, lying along the shore of the lake. This is followed by four or five miles of the Georgia slate and then about two miles of granular quartz rock. Prof. Hall's section represents the latter as the Potsdam sandstone, but the Red Sandrock and all the Georgia slates are called "*Trenton and Lower Limestones of the Mohawk Series.*" His section is colored,—the Potsdam, pink, and his so-called Trenton, blue. The remainder of this section does not cross any of the rocks under discussion and need not be noticed here.

This locality must always be looked upon with much interest, as the trilobites which have brought about so great a change in the opinions of some of our best physical geologists were here first discovered. Prof. Hall placed these trilobites and the slates in which they were found in the Hudson river group, but as soon as he saw that this view was incorrect, he denied that he had ever examined this part of the country at all, and at the same time gave the public to understand that he had been induced to refer this Primordial Fauna to the top of the Lower Silurian by Sir W. E. Logan. He says that "after the descriptions had been printed and *a few copies distributed*,"* he learned that Sir W. was at that time actually investigating the rocks of that part of Vermont. He then delayed the final publication till the meeting of the American Association (in Springfield) and there showed him the descriptions and obtained his authority for the addition of the note in which Sir W.'s opinion is stated.† He says, "left to palæontological evidence alone, there never could have been a question of the relations of these trilobites which would at once have been referred to the primordial types of Barrande." "Sir William Logan" he says, "yields to the palæontological evidence," and says "there must be a break." "He gives up the evidence of structural sequence which he had before investigated and considered conclusive; *and having heretofore relied upon the opinion* of the distinguished geologist of Can-

* May we be permitted to ask, to what formation are the Georgia slates referred in these "few copies" which were distributed before he obtained Sir W. E. Logan's opinion? Are they referred to the Hudson river group or to Dr. Emmons's Taconic System?

† Does he not here admit that the 12th Regents Report was altered by him in an important matter after the date of its publication.

ada *in regard to a region of country to which my own examinations had not extended*, I have nothing left but to go back to the position sustained by palæontological evidence."* As I understand this, it means that he never examined the country in the neighborhood of the Georgia locality of trilobites, and if he did not, then this section must have been compiled from the observations of of some one else. At all events the section proves very clearly that at the time he drew it up he did not know the age of the Red Sandrock Series.

The next section crosses the state of Vermont from Burlington eastward. On the Vermont map the Red Sandrock is here three miles wide along the lake shore. On the east side of it is a belt of Eolian limestone, also about three miles in width. The whole of this is laid down on Prof. Hall's section as "*Trenton and Lower Limestones of the Mohawk Series becoming metamorphic.*" He represents the rock as being all of this kind from the lake shore half way to the Green Mountains. A few beds of the Potsdam sandstone are then indicated as coming out from under the so-called Trenton limestone in the town of Willston. In the Vermont map there is a small outlier of granular quartz rock just about this locality, lying partly in Willston and partly in Hinesburgh, but it is totally separated from the Red Sandrock. The remainder of this section does not cross any of the rocks under discussion.

The above two sections are on plate 1. I have not been able to procure plate 2, and do not know what its contents are. I have plate 3, on which are engraved three sections. The first of these crosses from Whitehall in New York, to the Green Mountains. It shows an exposure of both the Potsdam and Calciferous formations at Whitehall. There never was any dispute as to the age of the rock at this locality. It has always been referred to the Potsdam and Calciferous, but never identified (except by Dr. Emmons) with the Red Sandrock. On this section all the slates between Whitehall and the Green Mountains are referred to the Hudson River Group. But according to the Vermont map they are the Georgia slates and are therefore the Taconic slates of Dr. Emmons, which lie below the base of the Lower Silurian, as that formation was originally limited. On this section therefore is engraved precisely the same mistake with respect to the age of the rocks, as that which was published in the 12th Regents' Report, with regard to the Georgia slates. The granular quartz rock lying at the base of the Green Mountains, is called "Potsdam," as it is in the other two sections. The other three sections do not cross any of the Red Sandrock.

*** See Prof. Hall's letter to the Editors of this Journal, [2], xxxi, p. 220, March, 1861. In his last paper he seems to give the late Prof. Adams credit for having originated the mistake with regard to the Vermont rocks.**

The only comment that need be made upon all of the above, is that at the time Prof. Hall prepared the sections to which he has appealed, *he did not know the age of the Red Sandrock*, but merely supposed it might consist of the Trenton, Black River and Chazy (the limestones of the Mohawk series) in a metamorphic condition. In no place where the Red Sandrock occurs is there a vestige of the Potsdam laid down in his sections. The fact that he recognized the Potsdam in other places avails him nothing in this discussion.

I have also lately procured the Geological Report containing the letter referred to by Mr. Hitchcock.* It is published as an appendix to the Report. The following is a copy of it:

"C."

"*Letter from Professor James Hall, on eertain fossils in the Red Sandrock of Highgate.*"

"Albany, N. Y., September 17th, 1847.

My Dear Sir:—I have only now received your letter of the 10th instant, on my return from a geological excursion. I have examined the fossils and, as far as I can determine, they are all of the central portion of the buckler of a trilobite with a prominent narrow lobed glabella. The cheeks have been separated at the facial section, so that we have not the entire form of the head. The course of the facial section indicates that it terminated on the posterior margin of the buckler, and the glabella is narrower in front than behind — these two characters are inconsistent with Calymene, Phacops or Asaphus, the common genera, (as well as with several other genera) of our strata, but they belong to Conocephalus and Olenus. I am inclined to regard this fragment as part of a Conocephalus, of which I have not before detected a fragment in our rock. From its isolated character, therefore, I am able to infer little regarding its real geological position. The form known to me most like this one, is in the Clinton group of this state. I regret that more species could not have been found, or that some form in the preceding strata could not be obtained to compare with the others already known.

The meagre information of the two known species of Conocephalus is likewise an objection to any geological inference from the discovery of a species. All we know is that they are found in Graywacke, in Germany, or elsewhere, and the position of the Graywacke is too dubious and ubiquitous to be of any importance in such a case.

I regret exceedingly that I am able to give only this meagre and unsatisfactory information, and also that I have not had the satisfaction of seeing the localitty.

I shall see you in Boston next week, if I am able to go there, and will there reply more fully to the other part of your letter respecting New York fosssils.

I have prepared nothing for our meeting but am coming to see what others do. I am very sincerely yours, &c., James Hall.

Prof. C. B. Adams."

* This Journal, [2], xxxii, p. 454.

"[Two specimens only have been obtained of a shell, which resembles Atripa Hemispherica, of the Clinton group of the New York system. Prof. Hall informs me that he is disposed to assign both the Clinton group and the Medina sandstone to one geological period.—C. B. A.]"*

This letter of Mr. Hall's proves the same thing that is established by his sections, i. e., that he was quite ignorant of the true age of the formation. The views of Prof. Adams on the age of the Red Sandrock must have been well known to all those engaged in the Taconic discussion, and most especially to Prof. Hall who has always been Dr. Emmons's leading opponent. The officers of three different geological surveys, namely, the survey of Vermost under Prof. Adams, the survey of Canada under Sir W. E. Logan, and the recent survey of Vermont under President Hitchcock, have at different times all placed the Red Sandrock in the horizon indicated in the above letter. They were all in constant communication with him, and in the Introduction to the 3d vol. of the Pal. N. Y., he claims priority over them all in the authorship of the very same views which he now seeks to charge upon them. In this last named work (p. 14) he says that the Hudson river group "may include all the beds from the Trenton limestone to the Shawangunk conglomerate." By this latter is meant the Red Sandrock. In the next sentence he says, "from the metamorphic slates of this group on the western slope of the Green Mountains in Vermont we have three or more species of trilobites which are of much interest, being representatives of a genus but little known in this country." These trilobites are no doubt the fossils of the Georgia slates which are called Trenton limestone in his sections. On page 15, he says:

"The opinions advanced by the writer (meaning himself) in 1844 and 1845, and published in the first volume of the Palæontology of New York, relative to the age of the rocks composing the metamorphic belt on the east side of the Hudson river, and including the principal part of the Green Mountain range, has been fully confirmed by Prof. Adams in the Geological Reports of Vermont. A re-examination of some portions of the same belt has added fresh evidence of the age of the formations, so far as included in Eastern New York, Western Massachusetts and Vermont."

He then gives Canada credit for contributing a good deal towards the confirmation of his views and closes at the foot of page 16 with "Geological structure therefore, and chemical and *palæontological* evidence all unite in proving the age of these deposits."

I shall only add that all the physical geologists engaged in this investigation with whom I have conversed on the subject,

* See "Third Annual Report on the Geology of Vermont." By C. B. Adams, State Geologist, &c., p. 31, 1847. Appendix C.

have assured me that Prof. Hall never gave them the least hint that the fossils proved a more ancient horizon than that indicated by the apparent attitude of the strata, but on the contrary always spoke of them as characteristic of the Hudson River group.* And so perfect was their confidence in the soundness of his opinion that it never occurred to them that he could be wrong, especially as every physical arrangement of the strata seemed positively to confirm his views. It was his duty to keep the fact always prominently before their minds that there was an antagonism between the physical and palæontological evidence. What the results would have been had he adopted this course is now apparent. As soon as the mist of erroneous palæontology was dispelled, the structure seen under a new light presented no difficulty of importance, and moreover many of the minor points which seemed to be very perplexing are now seen to be perfectly explicable.

Montreal, March 11th, 1862.

* The fossils alluded to here are those of the slates at Bald Mountain in New York published as Hudson River in the 1st vol. of the Pal. N. Y. in 1847, and also those of the Georgia slates in Vermont. Prof. H. never mentioned the *Conocephalites* to the Canadian Surveyors. The whole question has always rested on the correctness of the determination of the first of these, which are the original Taconic fossils on which Emmons depended. If Prof. Hall had been correct with regard to these, then all the Physical Geologists who sided with him would have been right as to the age of the Sandrock. The formation would be about the age of the Medina Sandstone. In fact he could not call the Red Sandrock Potsdam without contradicting in the most positive manner his own views as published in his first volume. Of course the Physical Geologists were well aware of Dr. Emmons opinions but nothing could shake their confidence in Prof. Hall. Even after the primordial aspects of the Georgia trilobites were pointed out, and for several months after the discovery of the Quebec fossils, they were very unwilling, as I know from my own experience, to believe that he could be wrong, especially as the physical structure seemed to confirm his views in the most remarkable manner. E. B.

ART. XXXIX.—*Discovery of Microscopic Organisms in the Siliceous Nodules of the Palæozoic Rocks of New York.*

AT Prof. Dana's suggestion, Dr. M. C. White, well known for his devotion to the microscope, has examined various specimens of the hornstone nodules found in the Devonian and Silurian rocks of this country, with a view to determine the presence of organisms analogous to those well known to exist in the flints of the Chalk. This research has been rewarded by the discovery of abundant organisms referable to the Desmidieæ, besides a few Diatomaceæ, numerous spicula of sponges, and also fragments of the dental apparatus of Gasteropods. Among the Desmids, there is a large variety of forms of Xanthidia supposed to be the Sporangia of Desmids, besides an occasional duplicated Desmid; also, lines of cells, some of which appear to be sparingly branched. The researches have been mostly confined to the hornstone of the Corniferous limestone; though extended also to the hornstone from the Black River limestone and that of the Sub-Carboniferous limestone of Illinois, both of which contain some organisms.

The hornstone nodules from the Black River limestone (as well as the Corniferous) have been since examined also by Mr. F. H. Bradley with similar results.

These observations will be regarded with much interest by geologists as well as by microscopists. They carry back to a very early epoch forms of life which have hitherto been looked upon as belonging only to a much more recent era in the life of our planet.

The analogy of these hornstone nodules to the flints of the Chalk is obvious; and the discoveries here announced may be regarded as establishing their similarity in origin. The organisms figured so closely resemble those of the flint that they might be taken for them; it is difficult in all cases to make out a difference of species.

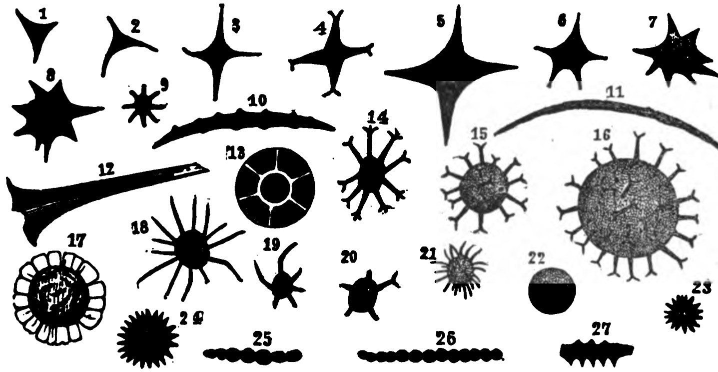
The extreme abundance of the hornstone nodules in our palæozoic limestones will render it easy to multiply observations in this new field of research, which presents an interesting addition to the labors of the microscopist. It will be remembered by those who undertake such examinations that the use of turpentine renders the chips of chert almost as transparent as glass.

We add a note from Dr. White with figures of some of the more frequently recurring forms hitherto observed by him.—*Eds.*

TO THE EDITORS:

Having recently been engaged in examining the microscopic structure of hornstone from Palæozoic rocks, I send you the accompanying sketches of organic forms which I have discovered. They consist of spicules and gemmules of sponge and fragments of sponges, Desmidieæ, several species of Xanthidia, and disks which probably are to be considered as Diatoms. Horn-

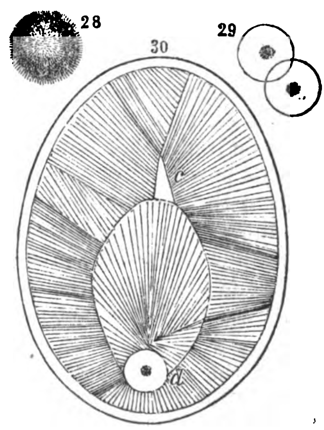
stone from the Corniferous limestone of central and western New York contains the greatest variety of these organic forms. A few specimens have been found in hornstone of the Black River Limestone from Watertown, N. Y.



Figures 10, 11 and 12 were drawn with a magnifying power of 70 diameters. Fig. 9 with a power of 400 diameters, and all the other figures with a power of 225 diameters. Figures 1 to 9, and 14 to 22, are various species of Xanthidia found in hornstone from the Corniferous limestone (Lower Devonian) of central and western New York. Figures 10, 11 and 12 are spicules of sponge from the same localities. Fig. 13 is a Diatom, on which the radial lines were faintly seen. Figures 23 and 24 are gemmules of sponge found in the hornstone of central New York. Figures 25 and 26 represent Desmidieæ, which are very abundant in the hornstone from Corniferous limestone of central and western New York. Fig. 27 is supposed to be part of a tooth of a Gasteropod.

Some of the specimens also contain spherical and ellipsoidal bodies 6-1000th to 7-1000th of an inch in diameter, the true nature of which has not been determined.

Figs. 28, 29 and 30 represent structures found in hornstone from the Black River limestone from Watertown, N. Y., magnified 225 diameters: 28 is a Xanthidium covered with very minute spines. 29 represents two Diatoms: 30 is a section of an egg-shaped body, $\frac{1}{100}$ inch in diameter, enclosed in a distinct shell, the ellipsoidal character of which was clearly shown in specimens from the Corniferous limestone, the shell being filled with very nearly transparent quartz. The specimen shown in the figure, found in the hornstone from the Black River limestone, is filled with a crystalline substance of a silky appearance, very nearly transparent. Near the larger end is a disk, *d*, which is probably to be regarded as a Diatom: *c* is probably a crystal. The thickness of the ellipsoidal shell is about $\frac{1}{2000}$ of an inch.



These investigations were undertaken at the suggestion of Prof. Dana, who furnished the specimens of hornstone, the examination of which has enabled me to make these most interesting discoveries. Yours, &c.

New Haven, Conn., March 22, 1862. M. C. White.

Art. XI.—*Colorado River of the West.**

For a number of years prior to the commencement of the present war in which our country is so unhappily involved, an annual appropriation of from 50,000 to 100,000 dollars has been made by Congress, for explorations and surveys in unknown regions west of the Mississippi, to be expended under the direction of the Topographical Bureau. Expeditions were therefore sent out to various parts of the West, with specific instructions as to the unexplored district to be examined, and a party organized, composed of topographers, meteorological observers, geologists, artists, &c., and placed under the command of an officer of the U. S. Topographical Corps. With an appropriation of 25,000 dollars, Lieut. Ives was ordered in the spring of 1857, to examine the unexplored region bordering upon the great Colorado of the West and to ascertain the navigability of that river. How well Lieut. I. and his assistants performed the duty entrusted to them the volume before us bears ample testimony. We regard it as one of the most important and most finished reports yet published by the U. S. government in regard to the West, and so far as the labors of the authors are concerned, it is in the highest degree creditable to them. While thus examining the Report before us with real pleasure we cannot but feel the profoundest regret that so able and accomplished an officer as Lieut. Ives, a native of New York City, but reared in New England, should at this time be found fighting in the ranks of the enemies of our country, lost to science and the world, at war not more with the government which has educated and advanced him than with his own convictions of right and duty.

We quote that portion of the introduction which relates to the history of Colorado explorations and the organization of the expedition.

"The Colorado of the West is the largest stream, with one exception, that flows from our Territory into the Pacific Ocean. It has its sources in the southern portions of Nebraska and Oregon, and in its course to the Gulf of California drains two-thirds of the Territory of New Mexico, and large portions of Utah and California, an area of more than 300,000 square miles.

Very little has been known concerning this river. Two streams, Green and Grand rivers, which flow through Utah in a southerly direction, have been supposed to unite somewhere near the southern boundary of

* Report upon the Colorado River of the West; explored in 1857 and 1858 by Lieutenant Joseph C. Ives, Corps of Topographical Engineers, under the direction of the office of Explorations and Surveys; A. A. Humphreys, Captain Topographical Engineers in charge. By order of Secretary of War. 364 pages 4to of text, with numerous engravings, 3 plates of fossils, 4 maps, two topographical and two geological.

that Territory and form the Colorado, but the point of junction has never been visited nor determined. For hundreds of miles below this point the stream has not been seen, till recently, by white men, excepting at one spot, and few Indians, for centuries past, have been near its banks. Notwithstanding this, some portions of the river were among the earliest parts of America to be explored. In less than fifty years after the landing of Columbus, Spanish missionaries and soldiers were travelling upon the Colorado, following its course for a long way from the mouth, and even attaining one of the most distant and inaccessible points of its upper waters. More information was gained concerning it at that time than was acquired during the three subsequent centuries.

In the year 1540 the viceroy of New Spain, interested in the accounts derived from a Franciscan monk of the latter's travels in the Territory now called New Mexico, sent an exploring expedition into that region under the command of Vasquez de Coronado. A detachment of twenty-five men, led by one Diaz, left Coronado's party and travelled westward. They discovered the Colorado and followed it to its mouth. Their description of the river and of the tribes they met upon it is not at all inapplicable to the condition of things at the present day, though the statements concerning the prodigious size of one community of Indians that they encountered are a little exaggerated. The Mojaves, to whom, doubtless, they refer, are perhaps as fine a race of men, physically, as can anywhere be found, but they do not quite come up, in stature and strength, to the descriptions of the Spaniards.

About the same time Captain Fernando Alarçon, by order of the viceroy, sailed up the Gulf of California and ascended the Colorado in boats for a long distance. The account of what he saw agrees with that of his cotemporary explorer.

Another of Coronado's captains, named Cardinas, with a party of twelve men, reached the pueblos of Moquis, and repaired from them, with Indian guides, to a portion of the Colorado, far distant from that seen by the others. The history states that after twenty days' march, over a desert, they arrived at a river, the banks of which were so high that they seemed to be three or four leagues in the air. The most active of the party attempted to descend, but came back in the evening, saying that they had met difficulties which prevented them from reaching the bottom; that they had accomplished one-third of the descent, and from that point the river looked very large. They averred that some rocks, which appeared from above to be the height of a man, were higher than the tower of the cathedral of Seville. This was the first description of the famous Big Cañon of the Colorado.

Several times, during the succeeding two centuries, the lower part of the river was visited by Catholic priests. In 1744 a Jesuit missionary, named Jacob Sedelmayer, went thither, following the course of the Gila, and travelled extensively in both New Mexico and Sonora, and about thirty years afterwards the Jesuits established missions among the Yuma Indians, who live at the junction of the Gila and Colorado. The priests were subsequently massacred by the fierce tribe among whom they had located themselves.

In 1776 another Catholic missionary, Father Escalante, travelled from

Santa Fé to Utah, and having explored the region south of the Great Salt Lake, pursued a southwesterly course, towards the sources of the Virgin, and then crossed to the Colorado, which he reached at a point that appears to have been almost identical with that attained, from the opposite direction, by Cardinas, more than two centuries before.

From this time the river was scarcely approached, excepting by an occasional trapper, or some overland party crossing the lower portion, *en route* to California. A considerable part of the emigration, induced by the gold discoveries in that region, passed through New Mexico, by way of the Gila, and the travellers were subjected to molestation from the Yumas. In 1850 a detachment of troops was sent to the mouth of the Gila to keep these Indians under control, and not long afterwards a military post, called Fort Yuma, was regularly established.

The difficulty of furnishing supplies to the garrison, across the desert, was such that, in the winter of 1850 and 1851, General Smith, commanding the Pacific division, sent a schooner from San Francisco to the head of the Gulf of California, and directed Lieutenant Derby, topographical engineers, to make a reconnaissance, with a view of establishing a route of supply to Fort Yuma, *via* the Gulf and the Colorado. The result of the reconnaissance was successful, and the route was at once put in operation. The freight, carried in sailing vessels to the mouth of the river, was transported to the fort—the distance to which, by the river, is one hundred and fifty miles—at first in lighters, and afterwards in steamboats.*

In 1851, Captain Sitgreaves, U. S. topographical engineers, with a party of fifty individuals, made an exploration from Zuni westward. He struck the Colorado at a point about 160 miles above Fort Yuma, and followed the east side of the river, keeping as near to the bank as possible, to the fort. He encountered the Mojaves, and found their appearance and customs generally to agree with the descriptions of the early explorers. The descent was accompanied with hardship and danger. Both the Mojaves and Yumas were hostile, and the difficulty of travelling near the river was extreme, owing to the chains of rugged and precipitous mountains that crossed the valley. The summer heats had parched and withered the face of the country; the stream was low, and what was seen of it did not create a favorable opinion regarding its navigability.

In the spring of 1854 Lieutenant Whipple, topographical engineers, in command of an expedition for the exploration and survey of a railroad route near the 35th parallel, reached the Colorado, at the mouth of Bill Williams's Fork, and ascended the river about fifty miles, leaving it at a point not far below where Captain Sitgreaves had first touched it. The expedition was composed of nearly a hundred persons, including the escort. The Mojaves were friendly, furnishing provisions to the party, whose supply was nearly exhausted, and sending guides to conduct them by the best route across the desert westward. The river was probably higher than when seen by Captain Sitgreaves, and it was the opinion of Lieutenant Whipple that it would be navigable for steamers of light draught. The course of the Colorado northward could be followed with the eye for only a short distance, on account of mountain spurs that crossed the valley

* A fuller account of the opening of this route is given in a subsequent chapter.

and intercepted the view. A high distant range, through which the river apparently broke, was supposed to be at the mouth of the 'Big Cañon,' which the Spaniards, in 1540, had visited at a place far above.

The marvellous story of Cardinas, that had formed for so long a time the only record concerning this rather mythical locality, was rather magnified than detracted from by the accounts of one or two trappers, who professed to have seen the cañon, and propagated among their prairie companions incredible accounts of the stupendous character of the formation. It therefore became a matter of interest to have this region explored, and to lay down the positions of the Colorado and its tributaries along the unknown belt of country north of the 35th parallel. The establishment of new military posts in New Mexico and Utah made it also desirable to ascertain how far the river was navigable, and whether it might not prove an avenue for the economical transportation of supplies to the newly occupied stations.

There was no appropriation that would enable the War Department to accomplish this service until the summer of 1857, when the present Secretary of War, having the disposition of a certain amount to be expended in field examinations, set apart a portion of it for the exploration of the Colorado, and directed me to organize an expedition for that object.

To ascertain how far the river was navigable for steamboats being the point of primary importance, it was necessary first to make provision for this portion of the work. The company employed in carrying freight from the head of the Gulf to Fort Yuma were unable to spare a boat for the use of the expedition, excepting for a compensation beyond the limits of the appropriation. A boat of suitable construction had, therefore, to be built on the Atlantic coast and transported to San Francisco, and thence to the mouth of the river. In order that the survey should be made at the worst and lowest stage of the water, I had been directed to commence operations at the mouth of the Colorado on the 1st of December. This left little time for preparation, considering that it was necessary to build a steamer and carry the parts to so great a distance.

In the latter part of June I ordered of Reaney, Neafie & Co., of Philadelphia, an iron steamer, fifty feet long, to be built in sections, and the parts to be so arranged that they could be transported by railroad, as the shortness of time required that it should be sent to California, *via* the Isthmus of Panama. About the middle of August the boat was finished, tried upon the Delaware, and found satisfactory, subject to a few alterations only. It was then taken apart, sent to New York, and shipped on board of the California steamer which sailed on the 20th of August for Aspinwall. Mr. A. J. Carroll, of Philadelphia, who had engaged to accompany the expedition as steamboat engineer, went out in charge of the boat.

The transportation of the steamer was, to the parties concerned, a source of more trouble than profit, but the kind offices of the agents of the Panama Railroad Company, and of the captains of the steamships on both the Atlantic and Pacific coasts, united to the careful supervision of Mr. Carroll, enabled the awkward mass of freight to reach San Francisco in safety by the first of October.

Dr. J. S. Newberry was appointed physician to the expedition, and

also to take charge of the natural history department. This gentleman had previously made extensive geological surveys in California and Oregon while attached to the party of Lieutenant Williamson, topographical engineers, in charge of the Pacific railroad surveys in those regions.

Mr. F. W. Egloffstein, who had been attached to Frémont's expedition of 1853, and had subsequently been employed with the party that explored the Pacific railroad route near the 41st parallel, was appointed topographer. Messrs. P. H. Taylor and C. K. Booker were the astronomical and meteorological assistants. A gentleman belonging to the household of Baron Von Humboldt, Mr. Mollhausen, who had been a member of the exploring party of Prince Paul of Wirtemburg, and also of Lieutenant Whipple's expedition, received from the Secretary of War the appointment of artist and collector in natural history."

The Journal of Lieut. Ives is full of interesting descriptions of incidents of the trip, accounts of numerous tribes of Indians, scarcely known prior to his visit, as the Moquis, Mojaves, &c. An important hydrographic report of 14 pages is also appended. We have room only for the vivid description of that remarkable passage in nature, the Black Cañon, given on pages 85, 86, and 87.

"*Camp* 59, *head of Black Cañon, March* 10.—The skiff having been put in tolerable order, a bucket full of corn and beans, three pairs of blankets, a compass, and a sextant, and a chronometer were stowed away in it, and a little before sunrise the captain, mate, and myself commenced the exploration of the cañon. My companions each pulled a pair of sculls, and with considerable vigor; but as the current has a flow of three miles an hour we could not make rapid progress. We had proceeded a quarter of a mile, and had just rounded the first bend, when one of the sculls snapped, reducing by half our motive power. There was, fortunately, a current of air drawing in the right direction through the narrow gorge, and, with the odd scull and a blanket, an apology for a sail was rigged, which, at intervals, rendered great assistance.

In a few minutes, having passed what may be called the outworks of the range, we fairly entered its gigantic precincts, and commenced to thread the mazes of a cañon, far exceeding in vastness any that had been yet traversed. The walls were perpendicular, and more than double the height of those in the Mojave mountains, rising, in many places, sheer from the water, for over a thousand feet. The naked rocks presented, in lieu of the brilliant tints that had illuminated the sides of the lower passes, a uniform sombre hue, that added much to the solemn and impressive sublimity of the place. The river was narrow and devious, and each turn disclosed new combinations of colossal and fantastic forms, dimly seen in the dizzy heights overhead, or through the sunless depths of the vista beyond. With every mile the view became more picturesque and imposing, exhibiting the same romantic effects and varied transformations that were displayed in the Mojave cañon, but on an enlarged and grander scale.

Rapids were of frequent occurrence, and at every one we were obliged to get out of the skiff, and haul it over. Eight miles from the mouth of the cañon, a loud sullen roaring betokened that something unusual was

ahead, and a rapid appeared which was undoubtedly the same that had been described by Ireteba. Masses of rock filled up the sides of the channel. In the centre, at the foot of the rapid, and rising four or five feet above the surface of the water, was a pyramidal rock, against which the billows dashed as they plunged down from above, and glanced upwards, like a water spout.

The torrent was swifter than at any place below, but a steamboat, entirely emptied of its cargo, which could be deposited upon the rocks alongside of the rapid, could, if provided with long and stout lines, be hauled up. During a higher stage of the river the difficulty of the place would be much diminished. With our nearly worn out ropes it would be very hazardous to attempt the ascent.

Several rapids followed at short distances, all of which would be troublesome to pass at the present depth of water. The constant getting out of the boat, and the labor of dragging it through these difficult places, made our progress for some miles exceedingly tedious and fatiguing. As sunset was approaching we came to a nook in the side of the cañon, four miles above the Roaring rapid, where a patch of gravel and a few pieces of drift wood, lodged upon the rocks, offered a tolerable camping place, and we hauled the skiff upon the shingle, and stopped for the night. There was no need of keeping a watch, with two grim lines of sentinels, a thousand feet high, guarding the camp. Even though we could have been seen from the verge of the cliff above, our position was totally inaccessible.

Darkness supervened with surprising suddenness. Pall after pall of shade fell, as it were in clouds, upon the deep recesses about us. The line of light, through the opening above, at last became blurred and indistinct, and, save the dull red glare of the camp-fire, all was enveloped in a murky gloom. Soon the narrow belt again brightened, as the rays of the moon reached the summits of the mountains. Gazing far upward upon the edges of the overhanging walls we witnessed the gradual illumination. A few isolated turrets and pinnacles first appeared in strong relief upon the blue band of the heavens. As the silvery light descended, and fell upon the opposite crest of the abyss, strange and uncouth shapes seemed to start out, all sparkling and blinking in the light, and to be peering over at us as we lay watching them from the bottom of the profound chasm. The contrast between the vivid glow above, and the black obscurity beneath, formed one of the most striking points in the singular picture. Of the subsequent appearance of things, when the moon rose higher, I do not think any of our weary party took particular notice.

This morning, as soon as the light permitted, we were again upon the way. The ascent of the river was attended with as much labor as it had been the day before; for though none of the rapids were of so violent a character, they were of constant occurrence. The wind still held to the south, and the blanket sail was again set to great advantage.

The cañon continued increasing in size and magnificence. No description can convey an idea of the varied and majestic grandeur of this peerless water-way. Wherever the river makes a turn the entire panorama changes, and one startling novelty after another appears and disappears with bewildering rapidity. Stately façades, august cathedrals, amphitheatres, rotundas, castellated walls, and rows of time-stained ruins, sur-

mounted by every form of tower, minaret, dome, and spire, have been moulded from the cyclopean masses of rock that form the mighty defile. The solitude, the stillness, the subdued light, and the vastness of every surrounding object, produce an impression of awe that ultimately becomes almost painful. As hour after hour passed we began to look anxiously ahead for some sign of an outlet from the range, but the declining day brought only fresh piles of mountains, higher, apparently, than any before seen. We had made up our minds to pass another night in the cañon, and were searching for a spot large enough to serve as a resting-place, when we came into a narrow passage, between two mammoth peaks, that seemed to be nodding to each other across the stream, and unexpectedly found, at the upper end, the termination of the Black cañon.

Low hills of gravel intercepted the view, and prevented us from seeing far into the unknown region beyond. A mile above the cañon the river swept the base of a high hill, with salient angles, like the bastions of a fort. At the base was a little ravine, which offered a camping place that would be sheltered from observation, and we drew the skiff out of the water, determining not to proceed any further until to-morrow. Leaving the mate to take charge of the boat, the captain and myself ascended the hill, which is over a thousand feet high. A scene of barren and desolate confusion was spread before us. We seemed to have reached the focus or culminating point of the volcanic disturbances that have left their traces over the whole region south. In almost every direction were hills and mountains heaped together without any apparent system or order. A small open area intervened between camp and a range to the north, and we could trace the course of the river as it wound towards the east, forming the Great Bend. In the direction of the Mormon road to Utah, which is but twenty miles distant, the country looked less broken, and it was evident that there would be no difficulty in opening a wagon communication between the road and the river. We tried to discover the valley of the Virgin, but could see no indication of any stream coming in from the northwest. The view in that direction was partially obstructed by another summit of Fortification rock.

Not a trace of vegetation could be discovered, but the glaring monotony of the rocks was somewhat relieved by grotesque and fanciful varieties of coloring. The great towers that formed the northern gateway of the cañon were striped with crimson and yellow bands; the gravel bluffs bordering the river exhibited brilliant alternations of the same hues, and not far to the east, mingled with the gray summits, were two or three hills, altogether of a blood-red color, that imparted a purely ghastly air to the scene.

The approach of darkness stopped further observations, and we descended to camp, having first taken a good look in every direction, for the smoke of Indian camp-fires, but without discovering any. In making the sixteen miles from last night's bivouac, we have had to labor hard for thirteen hours, stemming the strong current, and crossing the numerous rapids, and being thoroughly exhausted, depend for security to-night more upon our concealed position than upon any vigilance that is likely to be exhibited."

The greater portion of Lieut. Ives' report is in the form of a Journal, noting the current events of each day, in a style clear and attractive. His descriptions of the numerous cañons along the Colorado are exceedingly graphic and beautiful. On page 101 we have the following description of the side cañons of the Colorado, which are well depicted in the annexed engraving:

"A few of the Hualpais paid us a visit, but their intelligence is of so low an order that it is impossible to glean information from them, and their filthiness makes them ojectionable. Our new guides seemed to think we should have difficulty in ascending to the portion of the plateau which they traverse on the way to higher points upon the river. The route they ordinarily pursue follows the cañon of Diamond creek, but this they pronounced impracticable for mules, and said that we must retrace our course for several miles in order to strike a more circuitous, but easier trail, that ascended one of the branch cañons.

Following their advice and guidance, yesterday morning we toiled up the rough road by which we had come, for six miles, when they struck off into a side ravine that led towards the southeast. Half a mile from the mouth, the Hualpais told Ireteba that our camping place was just ahead, and scrambling over the summit of a hill, in a minute were both out of sight. For a mile we kept on, every few moments coming to a fork, where the selection of the right road was left to chance. There was a network of cañons, and the probabilities were that nine out of ten would lead to an impassable precipice. The ascent became so rough that it was already almost impracticable for the mules, and at last the Mojaves stopped, declaring that they had lost their way, and had no idea how to find the camping place or the water, and that the Hualpais were a very bad set. This opinion no one was inclined just then to dispute. I however asked one of the Indians to go back and endeavor to find the deserters or some other member of their tribe. We waited impatiently for half an hour, and then the order was given to countermarch, for I intended to search for the route by which we had come; but before going far, the little Hualpais came back. He seemed amused that we should not have been able to find the water, and again took his place at the head of the column. He conducted us for two miles through a difficult and intricate maze of ravines, and then climbed a side hill, and in a most unexpected place pointed out a little spring. There was a sufficiency of water, and tolerable grass near by. The second Hualpais came back during the evening, and seemed also to be astonished that we should have had trouble in finding what to him was so familiar. They both professed a determination to accompany the train, and Ireteba told me that it was time for himself and companions to return."

In securing the services of Dr. Newberry as Geologist and Naturalist of the expedition, the Department was fortunate—his well known ability in these branches of science, as well as his previous experience in connection with other expeditions in the far west, peculiarly fitting him for the task. His report is ably drawn up and contains lucid descriptions of the geological and physical features of the country along the line of exploration.

Side Cañons of the Colorado.

The numerous great gorges and profound cañons cut by the erosive action of water, through thousands of feet of strata, in a district where the rocks have, for the most part, suffered little or no disturbance since their deposition, afforded him a fine opportunity to study its geological structure. Probably in no other part of the world can so great a thickness of strata be seen and examined inch by inch in one continued section as here. These tremendous chasms cleaving the beds, as they do almost vertically sometimes to the astonishing depth of from three to six thousand feet, reveal every bed and layer of rock from top to base, as clearly and distinctly as they can be seen in the artificial excavations along our rail-roads.

In the great Cañon of the Colorado, on a high mesa, west of the Little Colorado, Dr. N. saw at a single exposure in regular succession the following formations:

1st. Upper Carboniferous limestone surmounting beds of cross-stratified sandstones, and red calcareous sandstones with gypsum, altogether, 1200 feet.

2d. Lower Carboniferous limestone, 1000 feet.

3d. A great thickness of limestone shales, and grits, apparently of Devonian age, resting upon heavy deposits of limestone, mud rocks, and sandstones, apparently of Silurian age, with a sandstone at the base, probably representing the Potsdam sandstone of New York: the whole not less than 2,300 feet.

Beneath all these stratified rocks the gorge is excavated so as to expose 1000 feet of granite.

Of these rocks Dr. Newberry remarks that, "the Silurian and Devonian strata are entirely conformable among themselves, and with the Carboniferous rocks. They lie nearly horizontal upon the granite, forming a series of sandstones, limestones, and shales, about 2000 feet in thickness. The Carboniferous series consists of over 2000 feet of limestones and gypsum, apparently all massive, and often highly fossiliferous. The upper members of the latter series form the surface of the mesas of the Little Colorada, upon which the volcanic group of the San Francisco mountains rest as a base."

At other localities Dr. N. had opportunities to examine the succeeding formations above those just alluded to. One of these, at the crossing of the Little Colorado, where one side of the valley is formed by a third mesa wall, which with the slope at its base rises to an elevation of at least one thousand feet in height above the stream.

"This mesa," he says, "is composed of deep-red sandstones, shales, and conglomerates, resting conformably on the Upper Carboniferous limestone, over which is a series of variegated marls, with bands of magnesian limestone. The latter series forms the surface of the mesa for many miles towards the northeast, and has an aggregate thickness of perhaps 1,500 feet.

The variegated marls and the underlying red sandstones are all regarded as Triassic by Mr. Marcou; but the marls exhibit a remarkable lithological identity from top to bottom, and the upper portion contain plants of Jurassic affinities. Without more fossils from these formations it seems to me, at least doubtful whether we can draw the lines of classification as sharply as he has done; and it would even be a little surprising if there should ever be found good palæontological evidence for the identification of all the European subdivisions of the Permian, Triassic, Jurassic, and Chalk, of which he claims to have demonstrated the existence in this vicinity.

Upon the mesa of the variegated marls at the Moquis village rises still another, to the height of 800 or 900 feet, composed of coarse yellow sandstones, green shales, and beds of lignite—a group of strata which has been called Jurassic, but which contain impressions of dicotyledonous leaves, with *Ammonites*, *Gryphœa*, and *Inoceramus* of Cretaceous species. These fossils leave no room for doubt in reference to the age of the strata which contain them, but prove them to be Lower Cretaceous."

The enormous thickness of strata is at places surmounted by another series of great thickness. This series is thus alluded to by Dr. N.

"Going north from the Moquis villages, on the Lower Cretaceous mesa, our progress was arrested by a want of water; the surface being everywhere cut by deep cañons, by which it is drained to excess; every rain drop which falls finding its way immediately into the bottom of these ravines, where it is hurried off to the far deeper cañons of the Colorado and its larger tributaries. Before we turned back, however, we had approached nearly to the base of a wall rising abruptly from the mesa in which we stood to the height of more than 1,000 feet. This wall was as white as chalk, and reflected the sunlight like a bank of snow. It is evidently the edge of another and higher plateau, and apparently reaches to the Great Colorado, where it caps the 'high mesa,' forming part of the stupendous mural faces, presented toward the south and west, which were distinctly visible when we had receded from them to the distance of a hundred miles.

What is the character of this upper mesa I had no means of determining at this time, and even now there may be some question about it; but I have scarcely a doubt that it is composed of the Upper Cretaceous strata, the equivalents of the 'white chalk' of Europe."

In regard to the causes which have produced the remarkable topographical features of this interesting region, Dr. Newberry shows that it is not due, as would probably be supposed by one not accustomed to the study of such phenomena, to volcanic or eruptive agencies, but solely to the erosive action of running water. Thus he continues:

"The sketch which has been given of the table-lands of the upper Colorado, though brief, will perhaps suffice to convey an idea of the generalities of their structure and relations. But before returning to the details of the local geology of our route, I ought perhaps to refer briefly to two questions of general import, which would naturally suggest them-

selves to any geologist who should traverse the table-lands west of the Rocky mountains, or should receive an accurate description of them from others.

The first of these questions is: To what cause is due the peculiar topographical features of the surface of the table lands—where the different formations succeed each other in a series of steps, which generally present abrupt and wall-like edges—the more recent strata occupying the highest portion of the plateau? The other has reference to the place and extent of the dry land, of which the erosion furnished the sediments now composing the table-lands.

The first of these questions belongs appropriately to the subject of surface geology, and will be referred to again. I may say here, however, that, like the great cañons of the Colorado, the broad valleys bounded by high and perpendicular walls *belong to a vast system of erosion, and are wholly due to the action of water.* Probably nowhere in the world has the action of this agent produced results so surprising, both as regards their magnitude and their peculiar character. It is not at all strange that a cause, which has given to what was once an immense plain, underlaid by thousands of feet of sedimentary rocks, conformable throughout, a topographical character more complicated than that of any mountain chain; which has made much of it absolutely impassable to man, or any animal but the winged bird, should be regarded as something out of the common course of nature. Hence the first and most plausible explanation of the striking surface features of this region will be to refer them to that embodiment of resistless power—the sword that cuts so many geological knots—volcanic force. The Great Cañon of the Colorado would be considered a vast fissure or rent in the earth's crust, and the abrupt termination of the steps of the table-lands as marking lines of displacement. This theory though so plausible, and so entirely adequate to explain all the striking phenomena, lacks a single requisite to acceptance, and that is *truth.*

Aside from the slight local disturbance of the sedimentary rocks about the San Francisco mountain, from the spur of the Rocky mountains, near Fort Defiance, to those of the Cerbat and Aztec mountains on the west, the strata of the table-lands are as entirely unbroken as when first deposited. Having this question constantly in mind, and examining with all possible care the structure of the great cañons which we entered, I everywhere found evidence of the exclusive action of water in their formation. The opposite sides of the deepest chasm showed perfect correspondence of stratification, conforming to the general dip, and nowhere displacement; and this bottom rock, so often dry and bare, was perhaps deeply eroded, but continuous from side to side, a portion of the yet undivided series lying below."

In an attempt to restore the physical geography of this region during the Palæozoic age, Dr. Newberry remarks:

"The question of the origin of the sediments composing the stratified rocks of the table-lands of the Colorado can scarcely be intelligently discussed till we know more than we now do of the geology of a large area lying north of the Colorado, and of the broad and compound belt of

mountains, which we have covered by a single name, (Rocky mountains,) but which, when carefully studied, will probably not be found to form a geological unity.

This much, however, we can fairly infer from observations already made on the geological structure of the far west, viz: That the outlines of the western part of the North American continent were approximately marked out from the earliest Palæozoic times; not simply by areas of shallower water in an almost boundless ocean, but by groups of islands and broad continental surfaces of dry land.

Since the erosion of rocks is always subaerial, or at least never takes place more than forty feet below the ocean surface, it follows that to form the stratified rocks of only that portion of the great central plateau which borders the Colorado, an island 300 miles in diameter, and at least 6,000 feet high, or, what is more probable, a continent of six times that area and 1,000 feet high, was worn down by the action of waves and rains, and in the form of sediments, sand, gravel, clay or lime, deposited on the sea bottom.

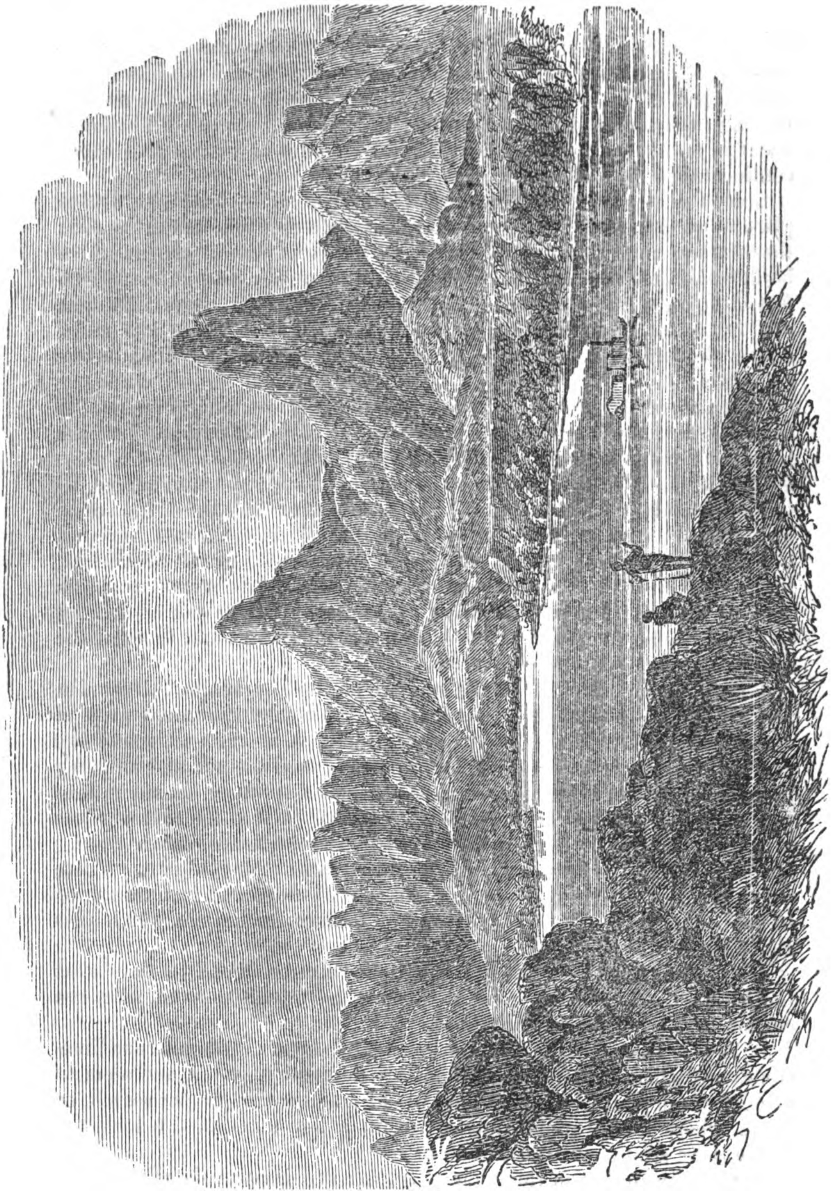
When we reflect that, with the exception of narrow wedges of erupted material in the mountains, an area having, on the 36th parallel, the breadth of the entire distance between the great bend of the Colorado and the Mississippi, (1,200 miles,) and a great, though yet unmeasured extension north and south is occupied by several thousand feet of Palæozoic and Secondary strata, we must conclude that these sediments have not been derived from the erosion of emerged surfaces east of the Mississippi, but here formed by the incessant action of the Pacific waves on shores that perhaps for hundreds of miles succumbed to their power and by broad and rapid rivers which flowed from the mountains and through the fertile valleys of a primeval Atlantis.

I have already alluded to the absence of the Silurian and Devonian rocks from the sections on the flanks of the Rocky mountain axes in New Mexico, while they occur in great thickness in the sections of the cañon of the Colorado, and that they were deposited around, and abutting in horizontal stratification against, the granitic spurs of the mountains bounding the table-lands on the west; and further, that the axes of these mountains are on the east side flanked by Carboniferous strata resting on the granite; the Silurian and Devonian rocks being absent. These facts show that the older Palæozoic strata were deposited in a trough or basin bounded on the east and west by granitic mountains which rose above the ocean's surface.

The Potsdam (?) sandstone which is largely developed in the Great Cañon is a coarse silicious rock that must have been derived from the erosion of land at no great distance.

It is true that the Silurian, Devonian, and Lower Carboniferous limestones are, where I examined them, nearly destitute of fossils, and seem to be deep-sea deposits, but shore lines would doubtless, by proper search, be found, where fossils are abundant, within a few miles of the localities where these strata are exposed on our route.

It would seem that in that vicinity (mouth of Diamond river) the water shoaled by the deposition of the sediments forming the older rocks, as the overlying Carboniferous strata abound in fossils, and one of the members



of that series, a sandstone, everywhere affords striking evidence of current action in its cross stratification.

In harmony with this fact is the occurrence of true coal measures with beds of coal, indicating emerged land at that epoch, north of the Colorado, at no great distance from this locality.

Hence the theory generally received that the formation of the continent began in a nucleus about Lake Superior, and that the places of the Rocky and California mountains were, until the Tertiary period, occupied by an open sea is proved untenable."

The engraving on the opposite page showing Chimney Peak range is thus described:

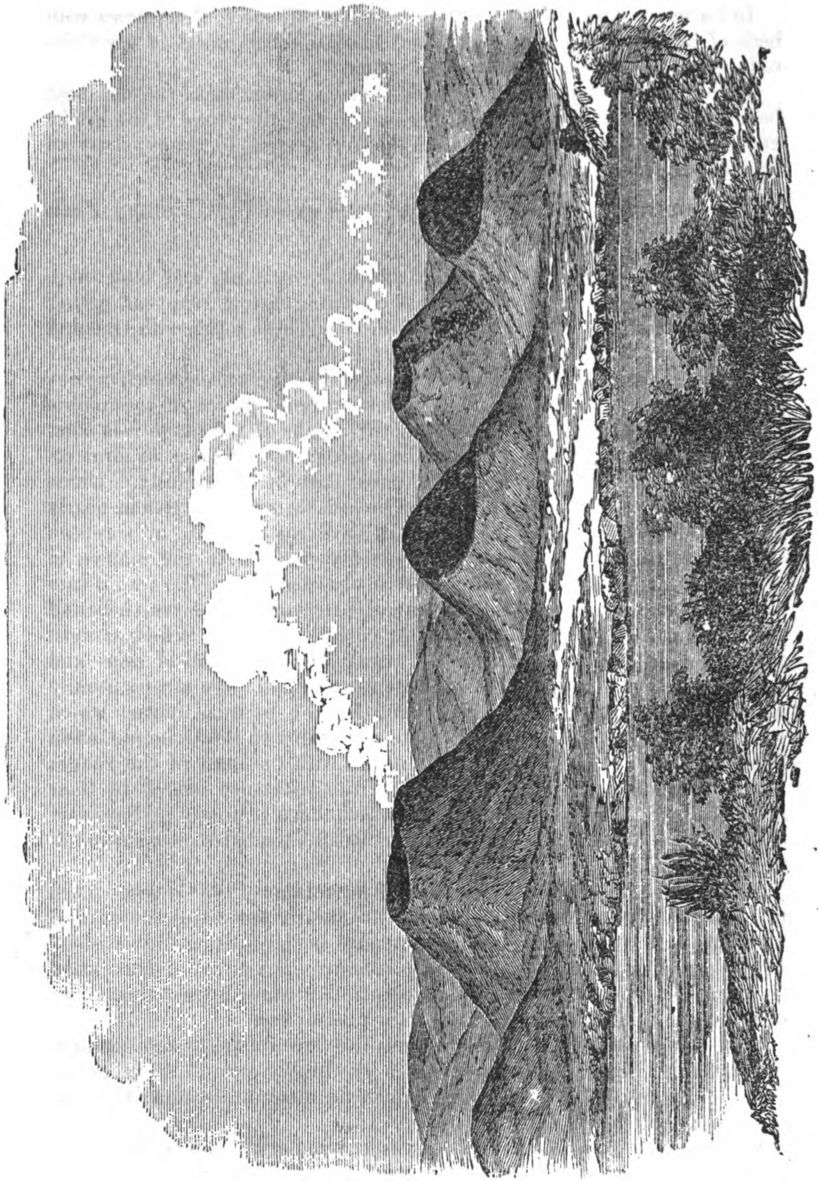
"Above the mica slate hills, red, white, green, pink, and blue tufas, porphyries, and trachytes, described as occurring below, reappear, giving the same fantastic appearance to the scenery. These rocks, with trap and scoria, extend from the river to Chimney Peak.

Chimney Peak is a remarkable picturesque double pinnacle which crowns a mountain chain, probably the northwestern prolongation of the middle range of the Purple Hills. Like the other peaks of the range it is composed of trap, and affords a striking example of the tendency to form columnar summits exhibited by all the mountains of this vicinity. Dome mountains on the east of the Colorado, present the same features in nearly an equal degree. The mountains which have this form are all trappeau in character, and doubtless owe their peculiar outlines to the manner in which this material yields to the action of the elements. The trap is usually more or less columnar in structure, the cleavage planes which bound the columns being perpendicular to the cooling surface. When, as most frequently occurs, these planes are vertical, by the erosion of rains and flowing streams, perpendicular walls are formed, and large masses usually exhibit mural faces. This will account for the peculiar outline which many of the trappean summits of the mountains of the Colorado basin present. Their great altitude, as compared with the mass of the ranges which they crown, is doubtless due to the resistance offered by their material to the atmospheric influences which have removed perhaps several hundred feet of the more yielding tufas and trachytes once surrounding them.

About the bases of some of the isolated mountains of the Colorado basin the material washed from the sides and summits has accumulated, and where these detrital slopes have been opened in the beds of the 'washes' I have described, I was able roughly to measure the amount of denudation the mountains had suffered. From these data it would appear that many of them have once been fully twice their present size.

At Precipice Bend and Barrier islands the river impinges against huge masses of red trachytes, west of which the highly colored rocks before described are very conspicuous, and extend for many miles along the base of Chimney Peak range.

"At intervals the sedimentary rock is covered with erupted materials, basaltic trap, scoria or ashes; and at several points are cones, once minor volcanic vents, and the sources from which these igneous rocks were de-



rived. Near our camp 84 is the most interesting group of these craters met with on our route, (see p. 402). Several of them are still very perfect in form, and long sinuous lines of black lava run down their sides—graphic records of their latest eruptions."

But we have neither time nor space to speak farther of this interesting and valuable report. Nearly 15,000 copies of it have been published by the Government, and it will doubtless be accessible to all who may wish to examine it for themselves. The authors have acquitted themselves with honor, the typography is clear and excellent, with very few errors, but with the exception of the scenic views and the topographical maps, the engravings are many of them quite poor. The maps which accompany this Report do great credit to the artistic skill and originality of Mr. Egloffstein, who has adopted a system of ruled tints by which the light sides of the mountains are relieved and the comparative altitudes of different levels exhibited, producing a most beautiful and effective picture of the topography, resembling a relief model. The maps are duplicated for the geology, the tints of the various formations being lightly and skillfully washed over them. The fossils are done in a harsh mechanical style of ruling, with little or no delicacy of tinting, and fail to exhibit to the eye of the Palæontologist their proper specific characters. There are comparatively few engravers capable of executing such illustrations in a style to be of service in the identification of species and creditable to the artistic skill of the country, and such persons rarely visit the seat of government to scramble after contracts; the consequence is that this kind of work, in too many cases, falls into incompetent hands. Proofs of engravings of objects of natural history ought *always* to be submitted to the careful inspection of the author or to some competent naturalist who shall have the power to accept or reject them, which has been, hitherto, seldom or never done.

We think we see in the future the dawn of better things, when mere political influence shall not control the publication of those scientific works with the proper execution which the national honor is inseparably connected.

Art. XLI.—*Enumeration of the Plants of Dr. Parry's Collection in the Rocky Mountains in* 1861; by Asa Gray. Continued from p. 243.

Since the first part of this Enumeration was published, Dr. J. D. Hooker's most interesting memoir, entitled "Outlines of the Distribution of Arctic Plants," has been received. This is of great importance in the study of any alpine or subalpine collection like the present, and has given occasion to a few remarks in the following pages. The memoir itself I expect to give some account of hereafter.

No. 79. Mr. Black, the obliging Curator of the Hookerian Herbarium, calling my attention to this number, enables me to correct an obvious error in my naming, in the first part of this enumeration. The plant is not *Ranunculus glaberrimus*, Hook., but an abbreviated subalpine state of *R. alismæfolius*, Geyer (the same as No. 306 of his collection), to which Bentham refers the *R. Flammula* of American authors.

I am well satisfied to see that Dr. Hooker, in his important paper on the Distribution of Arctic Plants, reduces *R. Eschscholtzii* to *R. nivalis*, L. Some specimens of Parry's No. 80 probably belonged to *R. affinis*.

104. *Cleomella tenuifolia*, Torr., from the district in which Dr. James discovered this species, so long taken for the original *C. Mexicana*.

105. *Cleome integrifolia*, Torr. & Gray. The *C. serrulata* is probably a nonentity, or a mere variety of this.

106. *Viola biflora*, L. This arctic-alpine species of the Old World had been traced all the way round to N. Japan and Kamtschatka, but was not before known as American, unless perhaps recently to Dr. Hooker, who has recorded it in his Tabular View,—perhaps on Dr. Parry's specimens, which may have reached him in time; or perhaps Bourgeau may have met with the plant.

107. *Viola Muhlenbergii*, Torr.; with some pubescent specimens belonging to the next.

108. *Viola Muhlenbergii*, var. *pubescens*, passing into *V. adunca*, Smith (*V. longipes*, Nutt.); which, except in its longer (seldom crooked) spur, as closely answers to the *V. arenaria* and *pumila*, as the ordinary *V. Muhlenbergii* does to the *V. sylvatica*, of the Old World. *V. adunca* should therefore have been added to the synonyms adduced by Dr. Hooker, in bringing all of this group under *V. canina*. Parry's specimens answer well to Bourgeau's from Saskatchawan.

109. *Viola Nuttallii*, Pursh; from the plains.

110. *Viola palustris*, L. From the alpine region, apparently, and the true *palustris*. The plant of our White Mountains is rather *V. epipsila*, Ledeb. Dr. Hooker goes a step too far in referring our *V. blanda* (with its lanceolate sepals and white flowers) to *V. palustris*. Our difficulty is to keep *V. blanda* clear of *V. primulæfolia*, and that clear of *V. lanceolata*.

111. *Geranium Carolinianum*, L.

112. *Geranium Richardsonii*, Fisch. & Mey.: "var. stylis profundius divisis nudiusculis." Engelm.

113. *Geranium Fremontii*, Torr.: "var. *Parryi;* caulibus pedunculisque patenter glanduloso-villosis; foliis minus profunde incisis, laciniis ultimis dentibusve ovatis obtusiusculis." Engelm.—The deflorate pedicels are sometimes declined.

114. *Gaura coccinea*, Nutt.

115. *Œnothera lavandulæfolia*, Torr. & Gray.

116. *Œnothera albicaulis*, Nutt., with pinnatifid leaves.

117. The same with undivided leaves.

118. *Stenosiphon virgatus*, Spach.

119. *Epilobium tetragonum*, L. Just like Swedish specimens.

120. *Epilobium alpinum*, L. The same genuine form was gathered by Mr. H. Engelmann at Bridger's Pass.

121. *Epilobium alsinifolium*, Vill. The same as the larger form in the alpine region of the White Mountains of New Hampshire. Dr. Parry notes it as probably a form of the last, and so we have regarded it.

122. Nearly the same as No. 119, but nearly smooth.

123. *Epilobium latifolium*, L. Perhaps its most southern station.

125. *Epilobium paniculatum*, Nutt.

124. *Gayophytum ramosissimum*, Torr. & Gray.

126. *Mentzelia albicaulis*, Dougl.

127. *Mentzelia* (*Bartonia*, Nutt.) *nuda*, Torr. & Gray.

128. *Sedum Rhodiola*, L. The female plant. "Along the borders of alpine brooks."

129. *Sedum rhodanthum* (sp. nov.): floribus hermaphroditis plerisque tetrameris pedicello plus duplo longioribus; sepalis linearibus; petalis læte roseis lanceolatis sensim acuminatis stamina (oppositopetala eis infra medium adnata) paullo superantibus; ovariis rectis; stylis filiformibus: cæt. ut in *S. algido* videtur. "High alpine region in moist places, at greater elevation than the preceding: fl. July." Petals nearly half an inch long, of a clear and deep rose-color, while those of *S. algidum*, of the Altaic Alps are described and figured as yellow, or dull rose-color with age, and blunt. As the stamens are adnate to the petals nearly as high as in *S. algidum*, it cannot be the doubtful *S. euphorbioides* of the elder Schlechtendal, from Arctic Siberia, which Ledebour, who took it up, regards as a possible variety of *S. algidum.*

130. *Sedum stenopetalum*, Pursh. All our species should be elaborated anew.

131. *Silene Drummondii*, Hook. The species of this group are much confused in the Flora of North America.

134. *Silene Scouleri*, Hook.

137. *Silene Menziesii*, Hook.

132, 133. *Lychnis apetala*, L. (*L. brachypetala*, Hornem.) Uniflorous and pauciflorous forms.

135. See *Gentiana*, among the Monopetalæ.

136. *Stellaria longifolia*, Muhl.

138. *Cerastium vulgatum*, the var. *Behringianum*, and *C. arvense*, L. mixed.

139. *Sagina Linnæi*, Presl.

140. *Arenaria Fendleri*, Gray, Pl. Fendl.

141. *Arenaria arctica*, Stev., var. γ, Torr. & Gray.

142. *Claytonia arctica* (Adams), var. *megarhiza:* foliis caulinis lanceolato-spathulatis seu lineari-spathulatis basi attenuatis quasi petiolatis; racemo intra folia subsessili (an semper?). *C. megarhiza*, Parry in litt., a name very probably to be adopted. "High alpine stations, extending to the crest of the snowy range; flowers from June to August. Grows in crevices of rocks, its large tap root penetrating to a great depth. Flowers, profuse, white with greenish-purple veins."—The large perpendicular root (about an inch in diameter), with the radical leaves and flowers, are just as in large specimens of *C. Joanneana*, Rœm. & Schult. (*C. acutifolia*, Ledeb. Fl. Alt. and Ic. Pl. Ross., t. 372, non Pall., Willd.) of which, confirmed by Trautvetter in Fl. Taimyrensis, I conclude that *C. arctica*, Adams (published two years earlier) is only a more arctic form. But the leaves of the cauline pair in our plant are much longer and narrower, tapering into a petiole, and they closely subtend the short raceme; wherefore this fine plant would most naturally, and perhaps more correctly, be taken as specifically distinct from the arctic-alpine Siberian one; in which view Dr. Parry's name is appropriate for it. I have seen no intermediate form. But after the experience we have had of the variability of the foliage of Claytonias, I prefer to risk the view here taken.

Aided by Dr. Parry's excellent specimens, I have now reviewed my MS. notes upon Pursh's *C. lanceolata* (which has been such a puzzle), and upon the related perennial species. It will be seen that Pursh's name, descriptive phrase, and figure do not accord; also that he adds, "*Pall. MSS.*," and states that he found in herb. Lamb. "a specimen collected by Pallas in the eastern part of Siberia, perfectly agreeing with the present species,"—doubtless the *C. Joanneana*, Roem. & Sch., of which I have seen Pallasian specimens. I have reason to think that Pursh's plate was made up from this Pallasian specimen and from the materials he had from Lewis, which last also perhaps comprised portions of two species. The radical leaves figured, which certainly are are not "lanceolate," are probably from the Siberian plant; the cauline of the plate are are not "ovate," and are narrower than I have observed them in any Siberian specimens,—in which, however, they are said to vary from ovate to elliptical: the naked corm, resembling that of *C. Virginica*, must belong to that *Claytonia* of the Rocky Mountains, &c., which is so nearly related to *C. Caroliniana*, but with sessile, oblong, linear-oblong, or even linear-lanceolate leaves, when dry 3-nerved from the base, i. e., the *C. lanceolata* of Hooker's Flora, and the *C. Caroliniana*, var. *sessilifolia*, Torr. in Pacif. R. R. Rep., 4, p. 70. Now, my notes, made in the year 1839, upon Pursh's materials in the Lambertian herbarium, state that the specimen there ticketed *C. lanceolata* by Pursh is the tuberiferous or corm-bearing plant, above-mentioned, and which may therefore, if permanently distinct from its eastern relatives, retain that name. With it is a specimen, ticketed by Pursh "*C. lancifolia*," having lanceolate-ovate cauline leaves. This may have furnished the model for the flowering stem of Pursh's figure, but it is not accompanied by any root or any radical leaves; while, as to the corm-bearing

species, these bear only single or very few radical leaves, and mostly none at all when the corm produces its flowering stem. The *C. lanceolata* of Hooker's Flora, as to the specimens, so accurately characterized in his remarks, is the same cormiferous species as Pursh's. But his specific phrase and the closing remark are evidently more or less influenced by Pursh's figure. The present discovery of a great tap-rooted *Claytonia* in the Rocky Mountains renders it not unlikely that Lewis and Clarke may have gathered the two species,—this without the root,—and that Pursh may have confounded them. However that may be, the names of the species concerned should stand as follows:—

C. LANCEOLATA, Pursh, fide herb., &c., for the corm-rooted plant of the Rocky Mountains and California, with sessile narrow leaves. Yet this is quite likely to prove a variety of *C. Caroliniana* (which also inhabits the valleys of the Rocky Mountains, both in New Mexico and in the British possessions), and that again runs insensibly into *C. Virginica.* It would appear that *C. lanceolata* extends to Kotzebue's Sound (Hook. & Arn., Bot. Beech. Voy., p. 123), and to the opposite Asiatic coast (Cham. in Linnæa, 6, p. 563). But Hooker and Arnott's *C. Virginica* from the latter region is probably

C. TUBEROSA, Pall. in Willd. Rel., ex Schult. Syst. 5, p. 436. *C. Virginica*, Willd. Herb. If I may rely on my notes taken in the herbarium of Willdenow in the year 1839, this plant of Pallas, with leaves as narrow as those of our *C. Virginica*, has the cauline ones closely sessile, and a *fusiform caudex* (so that the *C. Virginica* of Fenzl in the Flora Rossica is factitious); and I suppose that *C. Eschscholtzii*, Cham. l. c., is the same plant. Also that *C. acutifolia*, Pall. in Willd. Rel. l. c., is a broader leaved form of it, verging towards

C. ARTICA, Adams. This species (to which I dubiously append Parry's No. 142) was founded upon the most reduced and arctic state of the species to which belong *C. Sibirica*, Pallas in herb. Willd., but not of Linnæus,* *C. Joanniana* of Schultes, *C. acutifolia* of Ledebour, and *C. arctica*, var. *maxima*, of Chamisso.

143. *Talinum pygnæum* (sp. nov.), Gray in coll. H. Engelmann, Exped. Bryan. I know not if this is yet published. Parry's specimens closely resemble those gathered by H. Engelmann at Bridger's Pass, in the year 1856, except that they are larger and finer. It is an acaulescent species, with a fusiform perennial root, the crown bearing a cluster of linear or spatulate-linear leaves, with one-flowered and mostly bibracteolate peduncles in their axils.

144. *Ceanothus Fendleri*, Gray, Pl. Fendl.

145. *Ceanothus velutinus*, Dougl., near the var. *lævigatus*, Torr. & Gray.

146. *Berberis Aquifolium*, Pursh, var. *repens.*

147. *Papaver alpinum*, L. (*P. nudicaule*). High alpine.

148. *Callirrhoë involucrata*, Gray, Pl. Fendl., &c.

149. *Ribes lacustre*, Poir. An alpine form: "the common alpine

* The statement respecting the *C. Sibirica* of the Linnæan herbarium, made in the Flora of North America, 1, p. 476, and for which I am responsible, is not borne out by my MS. notes, which, on the contrary show that *C. Sibirica*, L., is entirely *C. alsinoides*, Sims.

Gooseberry, fruit reddish, hispid: flowers brownish," fewer in the raceme than in the common plant. This is probably *R. setosum*, Dougl.; at least it is the plant cultivated under that name, many years ago, by Loddiges.

150. *Ribes cereum*, Dougl. "Fruit reddish or amber-colored, insipid."

151. *Ribes hirtellum*, Michx. "Fruit dark purple, very acid."

152. *Ribes prostratum*, L'Her.

153. *Rhus trilobata*, Nutt., a variety of *R. aromatica.*

154. *Archangelica Gmelini*, DC. Dr. Hooker, in his paper on arctic plants, has referred not only the *A. littoralis* or *Norvegica* of N. Europe, but also *A. Gmelini* and *A. atropurpurea* to *A. officinalis.* I have already in more than one place insisted that *A. Gmelini* (the *Physolophium* of Turczaninow, *Cœlopleurum* of Ledebour, &c.) is a good *Archangelica;* but for want of good fruit of *A. officinalis* and *A. littoralis* I am unable to judge whether the latter connects *A. Gmelini* with the former. But I have no question (theories of derivation apart) that our *A. Gmelini* and *A. atropurpurea* are abundantly distinct, as well in their fruit as in their whole appearance. "Growing in truly alpine situations."

155. *Berula angustifolia*, Koch; a strict form.

156. *Conioselinum Fischeri*, Wimm. Just like the plant of the Northwest coast, and the *C. Tartaricum* of North Europe. But also not different, as far as I can see, from *C. Canadense*, so that we may extend the synonymy and range as given by Dr. Hooker. It ranges south to the mountains of New Mexico east of the Rio Grande, and in the Alleghanies to North Carolina.

Leptotœnia dissecta, Nutt., was gathered, a single specimen, at the foot of the Rocky Mountains.

157. *Cymopterus terebinthinus*, Torr. & Gray, var. *C. fœniculaceus*, Nutt.

158. *Cymopterus alpinus* (sp. nov.): caudice cæspitoso; foliis pinnatisectis, pinnis 3–5 approximatis 3–7-partitis, segmentis lineari-lanceolatis acutiusculis vel mucronatis integerrimis seu inferioribus 2–3-fidis; scapo 2–4-pollicari umbellam subcapitatam gerente; involucellis subunilateralibus 5–7-partitis, segmentis linearibus seu lanceolatis viridibus flores aureos adæquantibus; calycis dentibus lanceolato-subulatis persistentibus; alis fructus æqualibus suberoso-incrassatis vix undulatis; valleculis 1–2-vittatis, commissura 4-vittata; carpophoro nullo. "On high alpine ridges, along with *Primula angustifolia*, one of the earliest plants to flower." Leaves rather shorter than the scapes, glabrous, not glaucous, the margins minutely ciliolate-scabrous; segments 1½ or 2 lines long, in the smaller specimens only three in number. Fruit (of which very little was gathered) only 2 or 3 lines long. This is most probably the Umbelliferous plant collected by Dr. James in this same district, without fruit, and described in Dr. Torrey's account of James's collection, p. 207, but not named.

160. *Cymopterus montanus*, Nutt.

159. *Thaspium montanum*, var. *tenuifolium*, Gray, Pl. Wright.

161. Probably *Thaspium montanum*, Gray, Pl. Fendl. In flower only.

162. *Pachystima Myrsinites*, Raf. (*Myginda myrtifolia*, Nutt.)

163. *Saxifraga punctata*, L. (*S. æstivalis*, Fisch.)

165. *Saxifraga flagellaris*, Willd.; with scanty runners.

164. *Saxifraga Hirculus*, L. A very condensed, cæspitose, high-alpine form, the flowering stems barely two inches high, perhaps the same as *S. propinqua*, Brown, from the arctic shores. *S. serpyllifolia* of Pursh seems very near this, with smaller flowers, &c.

166. *Saxifraga Hirculus*, L. A small form, only 2 or 3 inches high, but quite like the common Arctic American specimens.

167. *Saxifraga cernua*, L.

168. *Saxifraga bronchialis*, L.

169. *Saxifraga nivalis*, L. Dr. Hooker might properly have cited *S. Virginiensis* as the temperate form of this species, and *S. vernalis* as a connecting form. *S. Virginiensis* stands independently in Hooker's list, resting on *S. reflexa*, Hook., from the shores of the arctic sea. I have never seen *S. reflexa;* but, from the character (especially the upwardly dilated filaments) and the fine figures in the Flora Boreali-Americana, I suppose that it is rather a form of *S. Dahurica*, to which *S. flabellifolia*, R. Br., also belongs.

A solitary specimen, from alpine brooks, may be *S. heiracifolia*, but it is too young for determination.

170. *Saxifraga cæspitosa*, L., var.; a very condensed alpine form: *S. uniflora*, R. Br.

171. *Mitella* (*Mitellaria*) *pentandra*, Hook.

172. *Heuchera bracteata*, Seringe. An interesting rediscovery of one of plants before known only from a single specimen in Dr. James's collection. According to Dr. Torrey, it accords with the original plant, but is larger-leaved. "Common in crevices of rocks, from the base of the mountains to alpine situations."

173. *Heuchera parvifolia*, Nutt.; a small state. "Strictly alpine, always exhibiting its close spikes, which are never elongated as in No. 174.

174. *Heuchera parvifolia*, Nutt., the taller form, exactly Fendler's No. 264, and Wright's 1098. "Valley of Clear Creek, common." Dr. Parry remarks: "I did not suspect this to be a variety of the former: its loose habit and long inflorescence seem to distinguish it; and no intermediate forms were noticed."

175. *Jamesia Americana*, Torr. & Gray; from the original habitat. The genus was founded, in the Flora of North America, upon a specimen so imperfect that it was omitted in the original account of Dr. James's collection. It is now well known, having been collected by Fendler, &c.; and, as it proves, the discoverer (now recently deceased) is commemorated by a most distinct and interesting genus.

176. *Trifolium dasyphyllum*, Torr. & Gray. Less downy than Dr. James's plant is described, the flowers considerably smaller than those of *T. alpinum.*

177. *Trifolium nanum*, Torr. "On the crest of high alpine ridges, in dense patches." This and the preceding are interesting re-discoveries.

178. *Trifolium Parryi* (sp. nov.): Involucrarium: glabrum, surculosum, subcaulescens; scapo 3–4-pollicari basi foliato; stipulis ovatis scariosis; foliolis oblongis argute dentatis; involucro scarioso 5–7-par-

tito capitulo plurifloro multum breviore, segmentis ovatis obtusis; calycis corolla rubro-purpurea subtriplo breviore, dentibus lato-subulatis tubum campanulatum subæquantibus; legumine sessili 3–4-spermo. "On high, grassy, alpine slopes. Flowers bright-red and purple, conspicuous." A well-marked species, very different from any of our involucrate species except *T. fucatum*, which has similar, but larger, stipules and corollas. Leaflets 6 to 12 lines long. Flowers 20 or more in the head. about 9 lines long, the corolla persistent and somewhat ampliate after flowering.

179. *Oxytropis splendens*, Dougl.

180. *Astragalus oroboides*, Hornem. *Phaca oroboides*, DC. *P. elegans*, Hook. I possess a mere fragment, without fruit, of the original *Phaca elegans* of Hooker's Flora; but I have a fine specimen, so named, from Bourgeau's Saskatchawan collection; and "*Phaca* No. 5" of the same collection is just like my original specimen of *P. elegans*, and like *P. oroboides* from Labrador communicated by Dr. Steetz. The latter and European specimens have rather less slender calyx-teeth; but no other difference is manifest. The elliptical and sessile legume has the dorsal suture more or less intruse. "*Phaca* No. 2" of Bourgeau's collection in the Rocky Mountains is probably a variety of *A. alpinus*, but has a shorter stipe to the legume and longer, very slender calyx-teeth.

181. *Astragalus* (*Phaca*, Hook.) *nigrescens*, Gray. *Homalobus dispar*, *multiflorus*, and *nigrescens*, Nutt.

182. *Astragalus alpinus*, L. *Phaca astragalina*, DC.

183. *Oxytropis Lamberti*, Pursh., if the flowers are purple as they seemingly are. Also *O. sericea*, Nutt., I presume.

184. *Astragalus*, near *glareosus*, Dougl., but the raceme many-flowered. Fruit not seen.

185. *Astragalus* (*Phaca*, Hook.). *Pectinatus*, Gray.

186 and 189. *Oxytropis Lamberti*, Pursh.

187. *Lathyrus ornatus*, Nutt. On the lower Platte.

188. *Lathyrus linearis*, Nutt.

189. *Astragalus gracilis*, Nutt.

190. *Astragalus* (*Orophaca*) *sericoleucus*. *Phaca sericea*, Nutt. Sand hills of the Upper Platte, May: in flower.

191. *Oxytropis nana*, Nutt. (*O. arctica*, var.?). "High valleys, rooting in granitic sand, in shade of *Pinus Banksiana*: rare."

192. *Dalea alopecuroides*, Willd. Doubtless from the plains.

193. *Astragalus Parryi*, (sp. nov.): cæspitoso-multicaulis e radice crassa, humifus, laxe villosus; stipulis fere discretis liberis ovatis, superioribus ex ovato lanceolato-subulatis; foliolis 15–21 ovalibus supra glabrescentibus glabrisve; pedunculis folium subæquantibus; racemo brevi 6–10 floro; floribus (6–8 lin. longis) subpatentibus; calycis dentibus attenuato-subulatis tubo oblongo-campanulato æquilongis; corolla ochroleuca ("viridulo-lutea") carina apice purpurascenti; legumine pollicari hirsuto coriaceo subinflato ovato-lanceolato acuminato incurvo uniloculari, suturis utrisque leviter intrusis. *A. succumbens*, Torr. & Gray, in Pacif. R. Road Rep. 2, (coll. Pope) p. 163, non Dougl. "Common in dry gravelly banks along Clear Creek: prostrate, with decumbent branches, matting the ground." Capt. (now General) Pope collected it in flower on the Llano Estacado, and Mr. Gordon in the same condition in the

Raton Mountains. It is with great unwillingness that one adds another species to this great genus, while several in the books are still imperfectly known. I had before referred this to *A. succumbens*, but the forming fruit of Parry's specimens shows that it is very different, and more allied to *A. glareosus*, Dougl. (*A. argophyllus*, Nutt.) yet it can hardly have been confounded with that species.

194. *Hosackia Purshiana*, Benth. Valley of the Platte.

195. *Dalea laxiflora*, Pursh. From the plains.

196. *Sophora sericea*, Pursh. Probably from the plains.

197. *Thermopsis rhombifolia*, Nutt.

198. *Psoralea lanceolata*, Pursh.

200. *Lupinus.* The same as Fendler's No. 168, which was doubtfully referred to *L. laxiflorus.* It cannot be named correctly until the related species are revised.

201. *Prunus* (*Cerasus*) *Virginiana*, L.

202. *Sibbaldia procumbens*, L.

203. *Dryas octopetala*, L.

204. *Geum rivale*, L. A specimen of this in fruit (in herb. Durand) collected at Eureka by Mr. Howard, has the head of carpels sessile; but still it appears to be only *G. rivale*, not *G. geniculatum.*

205. *Geum* (*Sieversia*) *Rossii*, Seringe. Large forms, a span high.

206. *Spiræa discolor*, Pursh. (*S. ariæfolia*, var. *discolor*, Torr. & Gray.)

207. *Spiræa opulifolia*, L., a small-leaved form, near the var. *pauciflora*, Torr. & Gray.

208. *Rosa blanda.* Ait.

209. *Cercocarpus parvifolius*, Nutt. The plant so long ago collected by Dr. James, but mistaken for the Mexican *C. fothergilloides.*

210. *Rubus deliciosus*, Torr. "A profusely-flowering shrub, abundant from the base of the mountains to the upper valleys, associated with *Jamesia.* Flowers white, never purplish. Fruit small, coarse-grained and insipid, ripening few largish grains." With Dr. Parry, I cannot doubt that this is James's *R. deliciosus*, notwithstanding the discrepancies. Those relating to the berries are principally a matter of taste, under different circumstances. The color of the petals was probably mistaken by the describer. To this species accordingly belongs my *R. Neo-Mexicanus*, Pl. Wright.

211. *Rubus Nutkanus*, Moçino.

212. *Rubus Idæus*, L. "Alpine."

213. *Potentilla fissa*, Nutt. In the mountains.

214, 215. *Potentilla nivea*, L. Slender forms.

216, *Potentilla Pennsylvanica*, L., var. *strigosa.*

217. *Potentilla concinna*, Richards.? a large form. At least a solitary specimen of undoubted *P. concinna*, from a higher station, is ticketed by Dr. Parry as a dwarf form of No. 217.

218, 219, 220, are forms of *Potentilla diversifolia*, Lehm, including *P. glaucophylla* and *P. Drummondii*, Lehm., and probably some others. The whole group requires complete revision and much reduction.

221. *Adoxa Moschatellina*, L.

(*To be continued.*)

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY.

1. *On the employment of the diffusion of liquids in chemical analysis.* —GRAHAM has applied the principle of diffusion with great success to the separation of substances of different diffusive power and has in some cases obtained results of remarkable accuracy. The author terms the process of separation in question *Dialysis.* Those substances which are uncrystalline in structure and which possess an extremely low diffusive power Graham calls *colloid,* and their state or condition the *colloidal* form of matter. Gelatin may be considered the type of this class of bodies. The colloid condition is strongly contrasted with the crystalline, or as Graham terms it, the *crystalloid,* the difference being not merely in the low diffusive power of the former, but also in the fact that colloids exhibit an intermediate state between solubility and liquidity, in many cases at least, and may serve as a medium for liquid diffusion like water itself. Colloids are further characterized by their changeable nature: fluid colloids readily become gelatinous or *pectose,* or pass back again from the pectose to the fluid state. The soluble hydrates of silica, alumina and analogous metallic oxyds, starch, dextrin, gum, albumen, gelatin, casein, &c., are colloids. Graham considers the colloidal form to be the dynamic while the crystalloidal is the statical form of matter.

A very simple method of separating bodies by diffusion consists in placing the mixture in a cylindrical glass vessel, five or six inches in depth, and filling the vessel with water very carefully so as not to disturb the matter at the bottom. After a few days the upper layers of water may be drawn off by means of a pipette and contain the most diffusible substances in solution.

For practical purposes it is convenient to employ an apparatus consisting of a flat round vessel in the shape of a sieve, the rim of which consists of gutta percha, and the bottom of parchment paper: the diameter of the vessel may be from eight to twelve inches, and its depth three inches. To illustrate the use of this apparatus, a mixed solution of gum and sugar may be introduced into the vessel so as to cover the bottom about half an inch deep, and the vessel allowed to float upon a larger quantity of water. In the course of twenty-four hours, all the sugar will be found to have passed through the membrane, and so free from gum that the solution is scarcely rendered turbid by basic acetate of lead, and yields by evaporation crystallized sugar.

Graham explains this action by supposing that the sugar takes up the water which the colloidal membrane has absorbed, and in this manner obtains a medium for diffusion, while the gum, which is a colloid, cannot separate the water taken up by the membrane and consequently cannot pass through. The author applies the method of dialysis to the preparation of colloidal substances in a state of purity, and even in many cases to analytical separations, as for example, to the separation of arsenous acid and other poisons, from liquids which contain organic matters. Thus if a few milligrammes of arsenous acid be introduced into

the dialytic apparatus with milk or other organic substances, after twenty-four hours the greater part of the arsenous acid will be found in the water beneath. This liquid, which the author calls the *diffusate*, is so free from organic substances that the arsenic may be precipitated directly by means of sulphuretted hydrogen.

If to a solution of albumen from eggs, acetic acid be added and the liquid be submitted to dialysis, the alkaline and earthy salts are rapidly diffused, and after three or four days, the albumen leaves no trace of ash. Albumen prepared in this way has a faintly acid reaction and still contains the sulphur which belongs to its constitution.

Half a liter of urine gave after a dialysis of twenty-four hours, the crystalloid substances contained in it, to the external water; this last on evaporation in a water-bath gave a white saline mass, from which alcohol extracted urea in such a state of purity as to crystallize on evaporation.—*Ann. der Chem. und Pharm.*, cxxi, 1, and *Phil. Trans.*, 1861.

In a note to the above paper Liebig calls attention to the fact that Graham's explanation of the diffusion of saline solutions through porous media, is identical with that which he had himself given in a paper on the causes of the motion of liquids in the animal body published in 1848, and which Graham appears not to have seen. Liebig further illustrates the importance of the method in examining the animal fluids, by a statement that flesh-broth, obtained by heating two parts of flesh with one of water in a water-bath, gave on dialysis an almost perfectly colorless diffusate, from which after concentration in a water-bath, very pure crystals of creatin were deposited, the other crystallizable substances in flesh being also present in the liquid. By a similar process, Liebig detected alloxan in a mucous discharge from the bowels. The importance of the method in the study of the chemical constitution of animal and vegetable secretions, can hardly be over estimated. W. G.

2. *On the determination of the density of vapors at low temperatures.*—Playfair and Wanklyn have given a method of determining the densities of vapors which depends upon the fact that permanent gases possess the property of converting vapors into true gases, or as the authors express it more accurately, the presence of a permanent gas acts upon a vapor in such a manner that its co-efficient of expansion for temperatures which lie near its point of evaporation, approximates to the co-efficient which obtains at the highest temperatures.

The authors remark that the mixture of a permanent gas may aid in distinguishing between the cases in which a vapor has an unusually high co-efficient of expansion and those in which an actual chemical change occurs. It is also possible by the employment of a permanent gas to determine the vapor densities of substances, which cannot be heated to the boiling point without decomposition.

In the case of those substances which may be heated above their boiling points, the authors employ Gay-Lussac's process for the determination of the vapor density. A slight modification of the process is however necessary. Before the glass bulb containing the weighed substance is introduced into the apparatus dry hydrogen gas is thrown up into the graduated tube and its volume measured with the usual precautions. In the subsequent calculation, the volume of the hydrogen reduced to the

normal temperature and pressure, must be subtracted from the reduced volume of the mixture of gas and vapor.

When the substance cannot be heated to its boiling point, the authors employ a process which is similar in principle to that of Dumas, but different in execution. Two bulbs, holding together about 300 cubic centimeters, are connected and drawn out on either side into a narrow tube. On one of these narrow tubes, three or four small bulbs are blown; the other is bent upward and then horizontally. The apparatus is weighed in dry air, introduced into a bath and a current of dry hydrogen gas passed through. The bath is then to be filled with warm water and the hydrogen current interrupted for a moment, in order that a small quantity of substance may be introduced into the apparatus. The substance is partially volatilized in the current of hydrogen and passes in the form of vapor into the large bulbs. The temperature of the bath is kept uniform in different parts and very gradually increasing. When the temperature has nearly reached that at which the determination is to be made, the current of gas is to be nearly interrupted, so that the bulbs contain less vapor than is sufficient to saturate the gas at the temperature of closing. The water is now allowed to flow out of the bath till the bends of the side tubes are uncovered, the bulbs remaining covered. The hydrogen current is then interrupted and the bends of the outer tubes sealed with the blowpipe, the temperature and pressure being observed. The volume of the apparatus is found by filling it with water and weighing, after determining the volume of the hydrogen contained. This is done by breaking off one of the ends under water, which rises into the bulbs, absorbing the vapor and leaving the hydrogen. The bulbs must now, without any change of temperature, be taken from the water and weighed with the contained water. The difference between this weight and the weight of the bulbs when completely filled with water, gives the weight of the contained hydrogen and consequently its volume; the pressure is the height of the barometer minus the column of water which enters the bulbs; the temperature is that of the water.

The authors have applied their experiments to acetic acid and other substances. At low temperatures, the vapor density of acetic acid is nearly 4·00, no matter how much hydrogen may have been employed. At higher temperatures, the vapor density approaches the number 2·00, while it is unnecessary to heat as strongly as in the experiments of Cahours.—*Ann. der Chem. und Pharm.*, cxxi, 101.

3. *On the analysis of spectra colored by metallic salts.*—Debray finds that the colored spectra obtained in the experiments of Bunsen and Kirchhoff may be projected upon a screen and rendered visible to a large audience by employing the flame of the oxyhydrogen blowpipe as the source of heat, instead of the ordinary gas burner. The metallic salt may be introduced into the flame by means of a little piece of gas-retort carbon. By employing the so-called Drummond's light, the inversion of sodium line D may also be projected on a screen; it is only necessary that the light should pass through the flame of an alcohol lamp containing salts in solution.—*Comptes Rendus*, liv, 169. W. G.

4. *On the spectra of phosphorus and sulphur.*—Seguin has examined the spectra produced by volatilizing sulphur and phosphorus in a current

of hydrogen and then passing the sparks from a Ruhmkorff's coil through the mixture of gas and vapor. The spectrum of phosphorus as thus obtained contains a red ray, an orange ray almost as brilliant as the red, two green rays less marked at the extremity of the visible portion of the green; after a comparatively dark space a blue-green ray, and then blue or violet rays which are not well defined. The orange and the two green rays appear or disappear according as the recipient containing the phosphorus is heated or cooled: they are therefore characteristic of phosphorus. The red and blue-green rays appear to belong to hydrogen though the phosphorus may contribute to the red.

Phosphuretted hydrogen gives the red, orange and blue-green rays, the two green rays not being apparent. Terchlorid of phosphorus mixed with hydrogen gives the orange, red and blue-green rays, as well as blue and green rays which belong to chlorine, and violet rays which may belong to both elements. The spectrum of the vapor of sulphur has a remarkable brilliancy when the temperature is high. It presents a red ray; three strong green rays almost equidistant, the first and second appearing almost yellow from their lustre, the third less vivid and apparently composed of finer rays; a greenish-blue ray, two blue and two violet rays. The three green rays are most characteristic: they are found also in the spectra of sulphydric and sulphurous acids. The author employed in his experiments a simple prism without telescope.—*Comptes Rendus*, liii.

W. G.

5. *On a new method of detecting and preparing the organic alkaloids.*—Erdmann and von Uslar have given a new method of separating the organic alkaloids which depends upon the fact that the free bases are easily soluble in hot amylic alcohol, while their chlorhydrates are so insoluble that they may be separated from the amylic solution by simply shaking this with water containing chlorhydric acid in solution. In preparing the alkaloids the material is to be extracted with chlorhydric acid, the extract treated with ammonia to set free the bases, and evaporated. The alkaloid may then be dissolved with hot amylic alcohol, the solution is to be shaken with water containing chlorhydric acid, which gives a pure solution of the chlorhydrate, while fatty and coloring matters remain dissolved in the amylic alcohol, which may be separated mechanically from the watery layer.—*Ann. der Chem. und Pharm.*, cxv, p. 121. W. G.

6. *Determination of carbonic acid in organic analysis.*—Mulder replaces in organic analysis the ordinary potash bulb apparatus by a tube filled with soda-lime. The apparatus which he employs consists of an ordinary combustion tube with a chlorid of calcium tube attached. To this last is attached a small U-shaped tube with small pieces of glass and from six to ten drops of concentrated sulphuric acid; after this comes a U-shaped tube, seven-eighths of which are filled with soda-lime, the other eighth with chlorid of calcium. Lastly, a tube filled with pieces of caustic potash is added; this is not weighed, but serves to prevent the influence of the air.

The chlorid of calcium tube and the U-shaped tube with the sulphuric acid are weighed together: the sulphuric acid tube enables the operator to watch the progress of the analysis. The soda-lime absorbs the car-

bonic acid completely; the chlorid of calcium serves to prevent the escape of water.

A U-shaped tube containing soda-lime and chlorid of calcium and weighing about forty grammes, will usually answer for two successive analyses; it is better, however, in the second analysis to add another and similar tube which should also be weighed before and after the analysis. When a current of oxygen is used to complete the combustion, it is necessary before weighing to fill the tubes with oxygen. If in the progress of the analysis, the sulphuric acid becomes brown, it may be inferred that volatile carburets of hydrogen have escaped combustion. The author asserts that this may be completelv avoided by filling the combustion tube completely with oxyd of copper and by not making a canal for the escape of the gases as is usually done. Numerous analyses show that the method is capable of giving very satisfactory results.—*Zeitschrift für Analytische Chemie*, i, p. 2. W. G.

7. *On the determination of lithium as phosphate of lithia.*—FRESENIUS finds that lithia may be determined quantitatively in the form of phosphate according to the method proposed by Mayer. A weighed quantity of pure carbonate of lithia was dissolved in dilute sulphuric acid, the solution evaporated, the residue gently ignited, dissolved in a little water, and evaporated with phosphate of soda and enough caustic soda to give an alkaline reaction. The dry mass was gently heated with water, an equal volume of ammonia added, the whole digested at a gentle heat, filtered after standing twelve hours, and washed with a mixture composed of equal parts of water and ammonia. The filtrate and washings were again evaporated, and the residue treated as before, whereby a further portion of phosphate of lithia was obtained. This process must be repeated as long as weighable quantities of phosphate of lithia are observed. In this manner, very satisfactory results were obtained. It must however be remarked that the author employs in his calculations, the old equivalent of lithium 6·5 instead of 7, as determined by Mallet. The phosphate of lithia has the formula PO_5, $3LiO$.—*Zeitschrift für Analytische Chemie*, i, p. 42. W. G.

II. GEOLOGY.

1. *Geology of Vermont.—Report on the Geology of Vermont; Descriptive, Theoretical, Economical and Scenographical;* by EDWARD HITCHCOCK, LL.D., ALBERT D. HAGER, A.M., EDWARD HITCHCOCK, Jr., M.D., and CHARLES H. HITCHCOCK, A.M. Two volumes 4to, pp. 988, with 38 plates, including a Geological map of the State, a map of the Surface Geology, several smaller maps, two plates of Fossils, several plates of scenery, and numerous wood engravings. Printed by Messrs. Goddard, Claremont, N. H., 1861.*—These two handsome, well printed and well illustrated volumes, are devoted to the elucidation of the geological structure and economical resources of a highly interesting and difficult region. They constitute a very important work for which all will feel thankful, not only to the excellent geologists whose labors are recorded therein,

* Copies of this Report may be procured by writing to A. D. Hager, Proctorsville, Vt.

but also to the people of the state of Vermont to whose well known patriotic spirit and love of advancement, science is now indebted for a valuable and most welcome contribution.

The greater part of Vermont has long been disputed ground between the advocates of several rival theories. Upon one of these,—the Taconic System, much light has lately been thrown, by discoveries made within this State as our readers are well aware; but there are other great problems such as the geological age of the Green Mountains and of several of the formations lying in the neighborhood of this chain which still remain. The officers of the Vermont Survey have wisely left these open, while at the same time they have given their own views and also published at length the opinions of other investigators who have arrived at opposite or somewhat different conclusions.

As the formations in this region are arranged in long rudely parallel belts running north and south, the work of the survey was carried on by measuring fourteen sections across the whole state in an easterly and westerly direction. The sections are engraved and colored to correspond with the colors of the map. In the text copious details are given descriptive of the lithological characters and attitude of the strata crossed by these lines. The geological column consists of 25 formations, embracing Azoic, Silurian, Devonian and Pleistocene-tertiary beds. We have space to notice only some of the more important observations.

A great belt of gneiss enters from the south and runs north through the whole length of the state, (about 160 miles) dividing it into two portions of which the eastern is somewhat larger than the western. This gneiss constitutes the principal mass of the Green Mountain range, and being both metamorphic and unfossiliferous, there are no means of determining its age except by its physical relations, whether above, or below, or on the same horizon with some one or more of the neighboring deposits whose chronology can be established. It would appear that the first step in this process is to ascertain the general structure of the range, whether it be upon the whole anticlinal or synclinal. If it be anticlinal then the gneiss must be, or most probably is, the most ancient rock in the state, with the exception perhaps of the Laurentian, of which latter there is a small exposure near Whitehall, at the south extremity of Lake Champlain. But if the gneiss constitute a synclinal, then it may represent some one or more of the Silurian or Devonian formations in a metamorphic condition. It is evident that this great problem can be solved only by good field-work. Mere library work will not do. The chapter relating to this formation is written by C. H. Hitchcock, and he is of the opinion that upon the whole the Green Mountains have an anticlinal structure. As the range runs the whole length of the state all the sections cross it. Six out of the fourteen sections exhibit the anticlinal structure perfectly and without any modification. In four others the strata all dip towards the east and may represent either inverted anticlinals or anticlinals which have passed into a fault and exhibit only the eastern limb. The remaining four consist of several folds each, but do not upon the whole indicate a synclinal form. These all relate to the main range of the Green Mountains, but a short distance east of this principal chain there is a smaller belt which does not run the whole

length of the state. Six of the sections including one drawn across a portion of Massachusetts just south of the Vermont line, cross this smaller range of gneiss, and five out of the six are perfectly anticlinal; the sixth shows two folds, an anticlinal and a synclinal. As the localities where these sections may be examined are pointed out, and very full tables of the dip and strike of the strata at numerous localities are given, Mr. Hitchcock has undoubtedly advanced this great question to such a position as to throw the *onus probandi* on those who maintain the synclinal theory. All physical geologists will admit that good field-work can only be opposed by field-work, and therefore those who hold that there are no mountains on the face of the earth except such as have a synclinal structure, will hereafter in dealing with this particular chain, find it necessary to leave the easy chair and library and take some exercise in the open air and on the rough hill side.

Lying along the western base of the Green Mountains is a great formation of sandstone or quartz rock, the celebrated "granular quartz rock" which Dr. Emmons places at the base or low down in his Taconic series. In the opinion of the Vermont surveyors it rests upon the gneiss and is a more recent formation. It holds a few fossils and the determination of these is of great importance, because the evidence they afford will sooner or later not only decide conclusively the age of the rock in which they are found, but also most assuredly bear strongly upon the question of the age of the gneiss. In 1847 Prof. Hall published in the 1st vol. of the Palæontology of New York, one of the species as *Scolithus linearis* and identified the rock with the Potsdam sandstone. It had been previously, in 1841, referred to the same by Prof. H. D. Rogers, who also quoted this fossil in proof of his opinion. Some other fossils were afterwards found by Prof. Adams in this formation and referred to Prof. Hall.

The granular Quartz Rock of Vermont

The following is his opinion as quoted in the Vermont Report, p. 356, from Foster and Whitney's Report upon the Land District of Lake Superior, 1851, p. 205. "I have recently received from Prof. Adams of Amherst, specimens of partially metamorphosed sandstone from Salisbury, Vermont, which he regards as the equivalent of the Potsdam sandstone. The specimens have all the characters of the purely quartzose variety of this rock, and contain fragments of crinoidal columns, and casts of an acephalous bivalve, similar to *Modiolopsis*. Such facts are highly interesting and promise important results for the future. Since however, no known fossils of the Potsdam sandstone occur with the rocks just mentioned, it requires a careful scrutiny to determine the age of the rock *in situ*."

Since that time a species of *Lingula* has also been discovered and was in 1860 placed in the hands of Mr. Hitchcock who referred it to Prof. Hall. The following is his opinion as quoted by Hitchcock, p. 500. "The Lingula though unsatisfactory, I regard as evidence of rocks of the age of the Clinton group of New York, or of Medina sandstone—a position reached by sandstones, a part of which we include in the Clinton and a part in the Medina sandstone."

It is to be regretted that these truly precious scraps of fossil evidence have not been carefully figured. A *Scolithus* very much like that of the Quartz Rock occurs in the Medina sandstone. No species of *Modiolop-*

sis has been found below the Chazy limestone in New York or Canada, although in the latter country one lamellibranchiate shell, a large *Conocardium* has been discovered in the Calciferous sandrock. The Vermont surveyors seem to have been to a great extent influenced by the fossil testimony as above interpreted in regarding the Quartz rock as of the age of the Medina sandstone.

The next formation of importance is the Eolian limestone, a vast deposit of crystalline rock 2000 feet in thickness, apparently overlying the Quartz rock. It is the Stockbridge limestone of the Taconic system and was first placed by H. D. Rogers in the horizon of the Lower Silurian limestone, including the Chazy, Black River and Trenton. It is found to contain several genera of fossils which have been referred to Prof. Hall for examination. With all deference we do not agree with him in his estimate of the weight of the evidence afforded by these remains. It appears that none of the species have been determined and that the conclusions were drawn from the range of the genera. *Euomphalus* both with round and angular whorls, the latter including *Helicotoma* (Salter) and *Ophileta* (Vanuxem) occurs abundantly in the Calciferous and Black River: and some of the species such as *H. planulata* and *Straparollus Circe* are very closely allied even specifically to Devonian and Carboniferous forms. No one can distinguish fragments of *Petraia* (*Streptelasma* Hall) from *Zaphrentis* without a knowledge of the age of the rock in which they are found. There is not the slightest generic difference between *Stromatopora* and *Stromatocerium* (Hall), the latter genus being abundant in the Lower Silurian limestones. *Stenopora* and *Ptilodictya* (*Chaetetes* and *Stictopora*) are also very prolific genera from the Chazy upwards. Very large round smooth crinoidal columns, such as those of *Cleiocrinus magnificus* occur in the Trenton. Wherever there are great deposits of Devonian or Carboniferous limestones, we are sure to find abundant remains of Brachiopoda of the genera *Producta*, *Chonetes*, *Spirifera*, &c., but no traces of these are reported as having been detected in the Eolian limestone. It would appear also that the fossils have been mostly found on the western side of the formation in Sudbury, Orwell, and Cornwall, in the neighborhood of the Red-sandrock which we now know to be about the age of the Potsdam. The evidence of the fossils therefore does not furnish any reasonable ground for placing this formation above the Lower Silurian. In the Report it is not positively placed in the Carboniferous system, the question being left open, but it is evident from the manner in which the fossils are quoted that that there is a very strong leaning in that direction. For this the surveyors are not responsible. The error is only a consequence of the old one, whose birth dates back to the publication of the 1st vol. of the Palæontology of New York.

The Eolian limestone appears to be developed upon a magnificent scale, and constitutes the principal portion of several ranges of mountains in the southern half of the State. Some of these, such as Mt. Eolus, exhibit a very perfect synclinal structure. They constitute however no part of the Green mountains, but independent ranges lying near and parallel thereto. The Quartz Rock forms a belt between the limestone and the gneiss. The gneiss appears to be the oldest rock; the

quartz rock the next younger and the limestone the most recent of the three.

We have noticed particularly the above three formations because the correct determination of their age must be made a starting point for future investigations in the large azoic tract lying east of the Green Mountains. In this latter region there is a narrow belt of Devonian limestone about one mile in width and 20 or 30 in length. All the rest appears to consist of unfossiliferous rocks of undetermined age, although their geographical distribution and general relations to each other are well made out and clearly defined on the excellent map and sections of the survey.

The western part of the State lying along Lake Champlain consists of the Lower Silurian and Primordial rocks, the most interesting being the Red-sandrock and Georgia slates so frequently noticed in our pages. There are also two formations of slaty rocks, the Talcoid schist and Talcose conglomerate, west of the Green Mountains, which we have not space to notice.

The first volume of this report opens with a preliminary chapter of 52 pages treating of the general principles of geology, metamorphism and classification of rocks and fossils. The remainder to page 555 is divided into three parts; the first relating to the recent and Tertiary deposits, the phenomena of drift and surface geology. The second, by E. Hitchcock, Senior, is devoted to the Palæozoic, and the third, by C. H. Hitchcock, to the Azoic rocks. The second volume contains parts 4 to 10 inclusive. The 4th part treats of the unstratified rocks; the 5th notes on the geological sections; the 6th, by E. Hitchcock, Jr., localities of minerals; the 7th, Chemical Analyses, by C. H. Hitchcock; the 8th contains two local reports; one relating to the geology of northern Vermont, by the Rev. S. R. Hall, and another on the geology of Plymouth, by A. D. Hager. The 9th, by A. D. Hager is an excellent and very full report on the economical geology of the State. The 10th, also by Hager, gives an interesting account of the Physical Geography, illustrated by 19 lithographic plates of the scenery for which Vermont is famous. The map is remarkable for the clearness with which the different formations are defined, and the colors are numbered to correspond with the numbers of the geological column. It is to be hoped that some such method as this last will be adopted for all maps. For the want of it, some elaborate works of this kind, such as the splendid map of Pennsylvania, can be understood only by much disheartening labor. Upon the whole we look upon this Report as one of the best that has been published on this continent. E. B.

Montreal, 18th March, 1862.

2. *On the date of the recently published Report of the Superintendent of the Geological Survey of Wisconsin, exhibiting the Progress of the work Jan.* 1, 1861. Madison, Wis.: E. A. Calkins & Co., State Printers. pp. 52, 8vo. By E. Billings.—This Report contains descriptions of about 60 species of fossils from the Silurian rocks of Wisconsin, by Prof. Hall, Superintendent of the Survey. A copy of it was sent to Prof. Dana by Mr. Hall, I understand, Dec. 27, 1861, but it was not received at the office of the Geological Survey of Canada until March 12th. Dr. Dawson noticed the first sheet in the December number of the Canadian Naturalist, which was published on the 1st day of Feb.,

1862. On one of the two copies received here is written (in a hand writing which I do not recognize) the words "Published Nov. 1861." The sheet noticed by Dr. Dawson was sent him by Prof. Hall in November or December. It is quite clear therefore that this publication is antedated at least 11 or 12 months. In November, 1861, I published a description of the genus *Obolella*, and pointed out the characters of a species from the Potsdam sandstone of Wisconsin. My paper was published on the 21st of Nov., and a copy sent to Prof. Hall on the 22d. On page 24 of his Report Prof. Hall describes the same species under the name of *Lingula polita*. His description of the interior of the shell is, in substance, the same as mine, and he expresses the opinion that the species is neither an *Obolus* nor a *Lingula*. Any person in possession of the two papers would come to the conclusion that I had taken the hint for the institution of the genus *Obolella* from Prof. Hall, as his report is dated nearly eleven months before mine. I take this opportunity of stating that I never saw his report nor had the least idea of its existence until the month of February, 1862, more than two months after my paper was published, and fourteen months after the date which he has placed on his title page. It is extremely disagreeable for me to write this, but any one can see that I am forced to do it or leave myself open to the charge of plagiarism, which does not attach to me in this case certainly. It is fortunate for American science that this practice is confined within an extremely small circle, otherwise many of the costly works published by the enlightened policy of many of the state governments of the United States would lose much of their authority. Whenever any of those dates prove to be erroneous I shall not hesitate to state it, as I have a perfect right to do, in the most public manner. E. B.

Montreal, March 24th, 1862.

3. *Correction of the Article on the Red Sandrock in this vol., p.* 100; by E. Billings.—In my paper on the Red Sandrock of Vermont, (this vol. p. 100) I have inadvertently said that Barrande first determined the age of the Georgia slates. My attention has been since called to this passage by one of the parties interested, who says that it seems to exclude Dr. Emmons from the discovery. Such an idea never occurred to me while writing the article. I should have said that with the exception of Dr. Emmons, Barrande was the first. I was aware of Dr. Emmon's opinion four or five years ago. Col. E. Jewett of the Geological Museum of the State of New York, wrote me several letters in 1857 and 1858 on the subject, and sent me specimens of the trilobites for examination. He strongly urged upon me the importance of investigating the matter. As we had not at that time any such fossils in Canada, and as I wished to keep aloof from the Taconic question, I did nothing further than to express my coincidence with them in their previously entertained views that the fossils had a true primordial aspect. In the winter of 1860 I brought them under Barrande's notice as constituting with some others a primordial colony in the Hudson River group. I said nothing to him about the Taconic question, and I included in the supposed colony three species of *Triarthus*. Barrande immediately replied that he did not think it a colony. While his letter was on the way we discovered the

Quebec trilobites, and before my letter communicating this new evidence reached him he had written to Prof. Bronn the letter which has already appeared in these pages, (see xxxi, p. 212). The Quebec fossils removed all doubt from my mind at once. But it was not until I had procured the opinions of Barrande, De Verneuil, Angelin, (the two latter through Barrande) Salter, Shumard and Safford, that the great weight of the opposing American authority could be removed. No one can claim, or professes to claim priority over Dr. Emmons, whose reputation as the originator of the idea of a pre-silurian fauna in America is world-wide.

In the table of fossils, p. 104, the species, *P. congregatus* belongs to the Vermont column and not to the other. Also the word *Koturgina* should be *Kutorgina.*

4. *Observations upon the rocks of the Mississippi Valley which have been referred to the Chemung Group of New York, together with descriptions of New Species of fossils from the same horizon at Burlington, Iowa;* by C. A. White and R. P. Whitfield. [Proceed. Boston Soc. Nat. History, vol. viii, p. 289 to 304, inclusive.]

This paper, or at least that portion of it received at this date, (March 13th,) contains descriptions of twenty-seven new species of fossils, which are referred to the following genera, viz:—*Orthis*, *Streptorhynchus*, *Spirifer*, *Retzia*, *Rhynchonella*, *Pentamerus*, *Aviculopecten*, *Mytilus*, *Orthonota*, *Nucula*, *Leda*, *Macrodon*, *Conocardium*, *Cypricardia ?*, *Cypricardella*, *Edmondia*, *Euomphalus*, *Platyceras*, *Pleurotomaria*, *Murchisonia*, *Porcellia* and *Bellerophon.*

These fossils were all collected at and near Burlington, Iowa, from a series of more or less arenaceous strata holding a position immediately beneath that member of the Carboniferous System in the west usually known as the Burlington limestone. In regard to the exact position in the Geological column, to which these lower beds belong, some difference of opinion exists. Doctors Owen and Norwood, and Mr. Pratten, included them in the Sub-Carboniferous series, as did Dr. Shumard and Prof. Yandell, Mr. DeVerneuil and others, equivalent strata at other localities in the west. Prof. Hall, however, maintains that these deposits represent the Chemung Group of New York, though as will be seen farther on, he not long since referred an equivalent stratum at Rockford, Indiana, to the Marcellus Shale, holding a position far beneath the Chemung, at the base of the Hamilton Group. Prof. Swallow and his assistants in the Geological Survey of Missouri, after identifying in the representative strata of that state, several of the same fossils known to occur in beds referred by Prof. Hall to the Chemung at other localities in the west, also placed them on a parallel with that rock.

More recently, Meek and Worthen, while investigating the fossils contained in the collections of the Geological Survey of Illinois, failing to find, after careful comparisons of extensive collections from these beds at numerous localities, a single species they could identify with any known Chemung form,—and finding them not only generally presenting close affinities to Carboniferous types both of this country and Europe, but in many cases in all respects undistinguishable from forms known to occur in well marked Carboniferous beds above, were naturally led to doubt the propriety of referring them to the Chemung epoch. These doubts were

strengthened by a knowledge of the intimate relations existing between these beds and the Burlington Limestone, (acknowledged Carboniferous) wherever they occur at the same locality,—the two rocks being always conformable, and never separated by any intervening beds,—while the Chemung Group is known to be separated at places in New York, from the proper horizon of the Subcarboniferous, by a great thickness of Old Red Sandstone, containing the remains of a peculiar fauna of its own.

The views of Meek and Worthen on this subject were given more in detail in a paper published in the September number of this Journal, commencing on page 167.* By reference to this paper, it will be seen, however, that the principal objects its authors had in view, were to show :

1st, That the Rockford Goniatite bed, which Prof. Hall had in a paper published in the Thirteenth Annual report of the Regents of the University of New York, referred to the horizon of the Marcellus Shale of the New York Series, is much more recent than that rock, and in fact an equivalent of the beds at Burlington, Iowa, which he had placed on a parallel with the Chemung Group.

2d, That the Black Slate of the west, which the same author had also regarded as belonging to the horizon of the Marcellus Shale, (his impression at that time being that the Goniatite bed was an intercalated layer in the Black Slate) instead of holding a position at the *base* of the Hamilton Group, comes in *above* all the Hamilton Group beds in Illinois—and from this fact, as well as from the affinities of the very few fossils hitherto found in it, more probably represents the Genesee Slate of the New York Series, as suggested by Prof. Yandell and Dr. Shumard, as well as by Mr. DeVerneuil.

3d, That the beds at Burlington, Iowa, referred by Prof. Hall in the Iowa Report to the Chemung, and their equivalents at Rockford, Indiana, and in Missouri and Illinois, ought not to be regarded as strictly contemporaneous with the Chemung Group of New York, but belong to a more recent period ; though they did not say they regarded it as demonstrated that these beds belong to the Carboniferous System.†

Some time during the same month that the paper above alluded to was published in this Journal, Prof. Hall issued a continuation of his paper in the Report of the Regents, containing a supplementary note in which he states that in consequence of having discovered amongst his specimens from a rock in Ohio regarded by him as representing the Chemung Group of New York, a Goniatite identical with one of the Rockford species, he has been led to modify his opinion in regard to the age of the Rockford Goniatite bed, so as to carry it up to the horizon of the Chemung. He also states that this discovery leads him to think "there is room to doubt" in regard to the relative position of the Hamilton Group and the Black Slate of the west, and whether this slate, "may be

* Remarks on the age of the Goniatite Limestone at Rockford, Indiana, and its relations to the "Black Slate" of the Western States, and to some of the succeeding rocks above the latter ; by F. B. Meek and A. H. Worthen.

† They likewise admitted that there may be some representation of the Chemung Group below the horizon of the Chouteau Limestone of Prof. Swallow, and its equivalents at Burlington, Iowa, and Rockford, Indiana, but denied that this had yet been clearly established.

regarded as a continuation of the Marcellus Shale, or the Genesee Slate of New York."

As the authors of the paper under review, raise no objection to the position taken by Meek and Worthen in regard to the Black Slate of the West representing the Genesee Slate instead of the Marcellus Shale, as had been maintained; and admit that the Rockford Goniatite bed does not, as had been asserted, represent a certain bed in the Marcellus Shale of New York, but belongs to the same horizon as the beds that had been referred to the Chemung at Burlington, Iowa,—it may, we think, be taken for granted that there is now no difference of opinion on any of the points, excepting in regard to the Rockford bed and its equivalent strata in Missouri, and at Burlington, Iowa, being newer than the Chemung.

In regard to this latter question, the authors of the paper under review, still maintain that these strata represent the Chemung group. They do not claim, however, to have identified a single Chemung species amongst the fossils of these beds, but on the contrary not only admit that they are, so far as known, all distinct from the species found in the Chemung of New York, but that they present strongly marked carboniferous affinities. One of the same authors also, not long since, showed in a paper published in the Boston Proceedings, that at Burlington, a number of the characteristic fossils of these strata pass up into the well marked Carboniferous beds above.

The grounds then upon which the identity of these rocks with the Chemung in New York, is maintained, is, that the *Goniatite* mentioned by Prof. Hall, and a few other fossils, the names of which are not given, from a bed in northwestern Ohio, regarded as a continuation of the Chemung, are considered identical with species in the rocks referred to that horizon west of the Cincinnati axis. At the same time it is admitted that the group of fossils found in the rock referred to in Ohio, also presents a strange and unaccountable similarity to Carboniferous types. The explanation of this anomaly given, is, that "we find in tracing these rocks [the Chemung] westward from New York, a tendency of the fauna to assume a decided Carboniferous character." And it is admitted that, "in some parts of northwestern Ohio, this character is as decided as that of the fauna of the Burlington limestone, &c." Hence the startling conclusion is arrived at, and stated as a general principle, that "if it is our desire, as far as possible to recognize formations over wide areas, that are already well known and named, it appears evident that we must ultimately be confined to the use of generic values, and relative position;" thus completely ignoring the use of specific affinities in the identification of strata at distantly separated localities, even in the same zones of latitude.*

If these conclusions are sound,—that is, if in tracing the same formation westward, which is in eastern New York characterized by an

* We are aware Prof. Agassiz has shown that the fossils of synchronous deposits in different zones of latitude, sometimes present much more marked differences than geologists have generally supposed. Yet it will scarcely be maintained, we think, that the striking differences observed between the fossils of the Chemung group in southern New York, and those of some of the beds referred to that epoch in northwestern Ohio, and at Burlington, Iowa, can be due to differences of climatic, or other physical conditions, dependent upon latitude.

acknowledged Devonian fauna, and holds a position beneath fifteen hundred to two thousand feet of other Devonian strata, we find it as we go westward from New York, assuming a more and more Carboniferous character, so that in northwestern Ohio, its fossils become as decidedly Carboniferous as those of the Burlington limestone; and that again in tracing it farther westward to the shores of the Mississippi, we find it not only presenting similar Carboniferous affinities, but so intimately connected by the mingling of its fossils with those of well marked and undoubted Carboniferous beds above, that no very sharp line of separation can be drawn between them,—we may reasonably infer that if the same beds were exposed midway between the Mississippi and the Rocky Mountains we should find them containing the remains of an Upper Carboniferous fauna, and in seeking for them at the Rocky Mountains, we should not look for Devonian, but Permian or Triassic fossils.

Surely before geologists admit such conclusions as these, striking as they do at the very foundation of geological science, they have a right either to question the identity of the few fossils mentioned from northwestern Ohio, with species occurring in the rocks referred to the Chemung, west of the Cincinnati axis, or to doubt that the particular beds in which they occur in Ohio, are exactly synchronous with the Chemung of eastern New York. Otherwise we may cast Palæontology to the winds, so far as the identification of strata is concerned.

But it is asserted with much confidence, that such are the facts, at least in tracing the Chemung westward from eastern New York to Iowa. It will, however, be remembered that it was just as confidently asserted recently, and that too, as was supposed, upon palæontological grounds, that the Rockford Goniatite bed and the Black Slate of the west, belong to the horizon of the Marcellus Shale; and yet it is now admitted that the first must be carried up at least as high as the Chemung, and that the latter *may* represent the Genesee Slate instead of the Marcellus Shale. Again it is not very long since it was maintained with quite as much confidence that certain rocks in Vermont containing Primordial types of *Trilobites*, belonged to the horizon of the Hudson River Group; yet, thanks to the profound palæontological skill of Mr. Billings, of Canada, and Prof. Barrande, of Bohemia, it is now known that they really belong far down at the base of the Silurian Series.

5. Geinitz: *Dyas, oder die Zechstein-Formation und das Rothliegende*, von Dr. Hanns Bruno-Geinitz, Leipzig, 1861—4°, pp. 130, 23 plates. —This exeellent memoir on the group of rocks called Permian by Murchison, has reached us from the author. We propose in a following number to notice some of the conclusions, and especially to present a comparison of the characteristic European and American fossils.

At this moment we will only add a few remarks on the name Dyas. It was first proposed in 1859 by Marcou, and signifies that the formation consists of two parts,—the marine beds of the Zechstein (Magnesian limestone) and the upper portion of the Roth-liegende (Red layers, Gres bigarré). These are conformable and are overlaid by the Trias.

It will be remembered that in 1859 Sir R. I. Murchison published in

this Journal (xxviii, 256), a notice of Marcou's Memoir entitled "Dyas et Trias," &c. The same author now reviews the arguments then used, and enforces it by new illustrations in a paper entitled, 'On the inapplicability of the New Term Dyas to the Permian group of rocks as proposed by Dr. Geinitz.' He aims to show that the term Dyas can be used only in open violation of all well established palæontological values—that it rests on certain lithological distinctions not essential or constant and is more objectionable than the kindred term 'Trias.'

He says "In borrowing the term 'Dyas' from Marcou, Dr. Geinitz shows, however, that that author had been entirely mistaken in grouping the deposits so named with the Trias or the Lower Secondary Rocks, and necessarily agrees with me in considering the group to be of Palæozoic age." After showing the reasons which in 1840–41 led him and his associates De Verneuil and Count Keyserling to propose the term "Permian" for the great group of sandstones, marls, pebble beds, copper ores, gypsums, &c., which have since been accepted under this designation, he adds:

"The chief reason assigned by Geinitz for the substitution of the word 'Dyas' is, that in parts of Germany the group is divided into two essential parts only—the Roth-liegende below, and the Zechstein above, the latter being separated abruptly from all overlying deposits.

"Now, not doubting that this arrangement suits certain localities, I affirm that it is entirely inapplicable to many other tracts. For, in other regions besides Russia, the series of sands, pebbles, marls, and gypseous, cupriferous, and calcareous deposits form but one great series. In short, the Permian deposits are for ever varying. Thus in one district they constitute a *Monas* only, in others a *Dyas*, in a third a *Trias*, and in a fourth a *Tetras*.* * * * *

"On my own part, I long ago expressed my dislike to the term Trias; for, in common with many practical geologists who had surveyed various countries where that group abounds, I knew that in numerous tracts the deposits of this age are frequently not divisible into three parts. In Central Germany, where the Muschelkalk forms the central band of the group, with its subjacent Bunter Sandstein and the overlying Keuper, the name was indeed well used by Alberti, who first proposed it; but when the same group is followed to the west, the lower of the three divisions, even in Germany, is seen to expand into two bands, which are laid down as separate deposits on geological maps of Ludwig and other authors. In these countries, therefore, the Trias of Alberti's tract has already become a Tetras. In Britain it parts entirely with its central or calcareous band, the Muschelkalk, and is no longer a Trias; but, consisting simply of Bunter Sandstein below, and Keuper above, it is therefore a Dyas; though here again the Geological Surveyors have divided the group into four and even into five parts, as the group is laid down upon the map—No. 62, 'Geographical Survey of Great Britain.'

"Respecting as I do the labors of the German geologists who have distinguished themselves in describing the order of the strata and the fossil contents of the group under consideration, I claim no other merit

* See 'Siluria,' 2d edit., 1859, and 'Russia in Europe and the Ural Mountains,' 1845.

on this point for my colleagues de Verneuil and von Keyserling, and myself, than that of having propounded twenty years ago the name of 'Permian' to embrace in one natural series those subformations for which no collective name had been adopted. Independently, therefore, of the reasons above given, which show the inapplicability of the word 'Dyas,' I trust that, in accordance with those rules of priority which guide naturalists, the word 'Permian' will be maintained in geological classification."

However the term Dyas, adopted by Dr. Geinitz as the title of his memoir, may be open to criticism, it is a pleasure to add that no recent memoir in geology does its author more credit or is more valuable in itself. We shall revert to it again with pleasure, as suggested above.

III. BOTANY AND ZOOLOGY.

1. *Botanical Necrology for* 1861.—The list includes the following names:—

Ferdinand Deppe, who in connexion with Schiede collected plants in Mexico, and to whom Chamisso and Schlechtendal dedicated the Rubiaceous genus *Deppea.*

A. E. Fürnrohr, the editor since the year 1843 of the "Flora oder Botanische Zeitung," of the well-known Botanical Society of Ratisbon.

Henckel von Donnersmarck, of Prussia, who must have reached a venerable age, as he published an Index to Willdenow's Species Plantarum in the year 1803, and other of his publications (which were small) are half a century old.

Rev. John S. Henslow, Professor of Botany in Cambridge University; born at Rochester in 1796; died at the rectory of Hitcham, Suffolk, May 16, 1861. Professor Henslow wrote the treatise on Botany forming the 75th volume of Lardner's Cabinet Cyclopædia; it was published in 1835, and did good service in its day. We are indebted to him, also, for an excellent Dictionary of Botanical Terms, recently published (without date) by Groombridge & Sons. Although the part which Prof. Henslow played in the direct advancement of the science was comparatively unimportant, his influence in botanical education, both at the University and in elementary schools, was very great, and his death left a void in England which is felt to be irreparable. Appreciative notices of his life and character were published in the Athenæum and in the Gardener's Chronicle.

Prince Salm-Dyck (*Joseph v. Salm-Rifferscheid-Dyck*) died at Nizza, his seat near the Rhine, in the 88th year of his age. His princely conservatories were devoted during a long series of years to the cultivation of succulent plants, which he assiduously collected from every part of the world, and illustrated in a series of monographs and catalogues, beginning with the genus *Aloë*, in 1817, and ending with the *Cacteæ in Horto Dyckensi*, in 1845. The good old prince—one of the mediatized at the dissolution of the German empire in 1806,—lacked little of being a century plant himself.

Prof. M. Tenore, the author of the *Flora Neapolitana*, and for 50 years director of the Naples Botanic Garden, the Nestor of Italian botan-

ists, died on the 22d of July last, at the age of 81 years. His earliest botanical publication appeared in the second year of the present century.

Jules M. C. Marquis de Tristan, of Orleans, died on the 24th of January, 1861, having almost completed his 85th year. He was the author of several botanical papers of interest, as well as of some metaphysical works, and even so late as the year 1851 he read a botanical communication to the Scientific Congress at its meeting at Orleans. It was for him that Brown in 1812 named the Myrtaceous genus *Tristania*, —a name which (the etymology being unexplained by its author) Sir James E. Smith, in the Encyclopædia Britannica, ingeniously attempted to derive from the Greek.

Prof. G. W. F. Wenderoth, of Marburg, died on the 5th of June last, at the age of 87. He was a pupil of Mœnch and his successor at the Marburg Botanic Garden, &c., and the author of numerous botanical works.

While preparing the above notices the sad intelligence is received of the death of three very distinguished botanists of Holland, at the commencement of the current year, viz:

Dr. R. B. Van den Bosch, of Goes, the acute monographer of *Hymenophyllaceæ*, and editor, in part, of the Bryologia Javanica after the decease successively of its original authors, Dozy and Molkenboer. (He died on the 18th of January, at the age of 51.)

Prof. Wm. H. DeVriese, of the University of Leyden, a most active and estimable botanist, author of many important works and memoirs. He died on the 23d of January last, at the early age of 55 years, only ten months after his return from a laborious and successful mission, under the appointment of the Dutch Government, to the Dutch East Indian possessions, to investigate their botanical resources and culture.

Dr. Charles Louis Blume, an older and still more renowned botanist, the curator of the Herbarium of the Royal Museum at Leyden, as we learn from the same source (Gard. Chronicle of Feb. 8), died a few days later than Dr. DeVriese, viz., about the first of February. Dr. Blume's earliest publications, issued at Batavia, while he was in charge of the Colonial botanic gardens of Java, bear the dates of 1823 to 1826. His later works, several of them of a magnificent character, come down to a very recent date. (He died on the 3d of February, in the 66th year of his age.)

Dr. Edwin James died at Rock Spring, near Burlington, Illinois, on the 28th of October, 1861, at the age of 64 years. As the earliest botanical explorer of an alpine region, in which Dr. Parry has recently much interested the readers of this Journal, it is with peculiar propriety that the following biographical notice of this pioneer of Rocky Mountain botany is furnished by Dr. Parry. A. G.

2. *Dr. Edwin James*, who is best known among scientific men in this country as the Botanist and Historian of Long's Expedition to the Rocky Mountains, in 1820, was born in Weybridge, Addison county, Vermont, on the 27th day of August, 1797. His father, Deacon Daniel James, was a native of Rhode Island, and removed to Vermont, about the commencement of the revolutionary war. Edwin, the subject of this sketch, was the youngest of ten sons, three of whom became physicians. His early studies were conducted at home, in the manner usual

at that period; the summer months being devoted to the labors of the farm, and the winter spent at the district school. From a youth he was noted for activity, application, and industry. He pursued his academic and collegiate course at Middlebury, Vt., where he was graduated in 1816. Subsequently he engaged in the study of medicine, for three years, under an elder brother, Dr. Daniel James, in Albany, New York. While pursuing his medical studies, he was particularly interested in the Natural Sciences, then taught by Prof. Eaton, under the distinguished patronage of the late Stephen Van Rensselaer.

In the spring of 1820, Dr. James was attached to the Exploring Expedition of Col. Long, as botanist and geologist, taking the place of Dr. Baldwin, who accompanied this expedition on the previous season as far as Franklin, on the Missouri River, where he terminated his labors and his life.

Dr. James was recommended to this situation, by Hon. Smith Thompson, Sec'ty. of the Navy, Capt. Leconte, and by Dr. John Torrey, whose subsequent labors as the descriptive botanist of Dr. James' collections, has intimately associated his name with this pioneer Expedition. The connection of Dr. James with the expedition, lasted till its close, being engaged in active exploration, during the season of 1820, from May to November.

The efficient labors of Dr. James, in this arduous trip, may be readily inferred from the published scientific results. Interesting additions were made to our knowledge of the botany of the great plains, at that time but imperfectly known. The elevated peaks, forming the outliers of the Rocky Mountain range, rivaling in altitude the snowy summits of Mt. Blanc, revealed a flora of exceeding richness, and attracted the attention of botanists both in this country and in Europe. We can easily imagine the enthusiastic ardor with which the young naturalist, treading for the first time these alpine heights, gathered up its floral treasures, and scaled the snowy peak, which ought properly to bear his name. It is still unexplained why the recommendation of Col. Long, applying to this mountain the name of *James' Peak*, has not been adopted, by modern geographers. Amid the great number of elevated landmarks, of this region, some other peak fully as appropriate, might have been selected to bear the name of the enterprising *Pike*.

On returning from this expedition, the attention of Dr. James was occupied, for about two years, in compiling the results of the same, which were published, both in this country and in Europe, in 1823. The work elicited no little interest, and is now a valued fund of historical and scientific facts.

On the completion of this work, Dr. James was for six or seven years connected with the United States Army, as Surgeon, serving in that capacity at several of the extreme frontier posts. During this period, aside from his professional duties, he was occupied with the study of the native Indian dialects, and prepared a translation of the New Testament, in the Ojibwe language; subsequently published, in 1833. He was also the author of a life of John Tanner, a strange frontier character, who was stolen when a child from his home on the Ohio River by Indians, among whom he was brought up, developing in his future eventful his-

tory a strange mixture of the different traits pertaining to his early life, and savage education.

On the reorganization of the medical department of the U. S. Army, in 1830, Dr. James resigned his commission, and returned to Albany, N. Y., where for a short time he was associate editor of a temperance journal, conducted by E. C. Delavan, Esq.

After leaving this, he concluded to make his home in the far west, and in 1836 he settled in the vicinity of Burlington, Iowa, where he spent the remainder of his life, devoted mainly to agricultural pursuits.

It was at about this time that some peculiar traits, which distinguished Dr. James as a *strange* man, became more conspicuous. His mode of life, his opinions, and his views on moral and religious questions generally, were inclined to ultraism. Failing to find earnest sympathy, among those with whom he was thrown in contact, he gradually assumed the habits of a recluse. Indifferent always to public opinion, he marked out, and pursued his own course, without regard to the views of others. Strictly honorable in all his dealings with mankind, and naturally kind-hearted, he did not care to waste his sympathy where it would not be appreciated. With him to espouse a cause, was to carry it to the farthest possible extreme, often erroneous, and it is to be feared at times positively wrong. In full justice however to his many amiable traits, it must be admitted that his errors were on the side of goodness, and in all his waywardness, he never forfeited his self-respect, or the attachment of those who had known him in early life. In his personal appearance, Dr. James was tall, erect, with a benevolent expression of countenance, and a piercing black eye.

"On the 25th of October, 1861, he fell from a load of wood, the team descending a small pitch of ground, near his house, and both wheels passed over his chest. He at once said that he was a dead man. He lingered, much of the time in great pain, until the morning of October 28th, when he expired at the age of 64 years." C. C. P.

3. *DeCandolle's Prodromus:* Pars xv, Sect. posterior: fasc. I. Jan., 1862, pp. 188.—This includes the genus *Euphorbia*, elaborated by the indefatigable Boissier, issued in advance of the rest of the *Euphorbiaceæ*, which are undertaken by J. Müller, also of Geneva. Boissier, who is a keen observer, admits about 700 species of *Euphorbia*. That is, he describes 963 species chiefly from his own knowledge, and adds seven which are imperfectly known and not recognized by him, not to speak of 23 wholly obscure ones in the books. So that the Linnæan genus *Euphorbia* (which Boissier has the good judgment to retain entire) rivals *Carex*, *Solanum*, and *Senecio* in vastness. Dr. Engelmann, who has specially studied our species, and to whom Boissier acknowledges his particular obligations, should offer comments, if any be necessary, upon the present arrangement, as respects the North American species. A. G.

4. *Illustrations of the Genus Carex;* by Francis Boott, M.D. Part III, tab. 311–411. London, W. Pamplin. 1862.—The first of these magnificent folios was issued in the year 1858; the second in 1860; the third is now, thanks to the extreme liberality of the author, in the hands of many of the principal botanists of this country. Our former

notices have explained the nature and extent of this great monograph. In this, as in the preceding volumes, Dr. Boott has favored the land of his birth and early years—and which would fain still claim him as her own,—by devoting half of his plates to the illustration of North American species. And with such generous profusion, such as only a love of Carices for their own sake could inspire,—lavishing four folio plates upon such a common and homely species as *C. vulpinoidea*, two upon the equally vulgar *C. stipata*, three upon *C. cephaloidea*, two upon *C. Muhlenbergii*, &c. The latter and their allies, however, as well as the group of *C. straminea*, are critical subjects, which the fullest elucidation will render none too clear. As Carices are still favorites with our botanists, we will enumerate the North American species which are illustrated in the present volume.

C. riparia, Curtis. To this European species, Dr. Boott restores our *C. lacustris*, and he figures North American specimens. It extends into South America, as far as to Chili and Montevideo.

C. alpina, Sw., including *C. Vahlii*, an arctic-alpine species.

C. atrata, L., including *C. nigra*, also arctic-alpine.

C. scoparia, Schk.; with its var. *minor*, from Arctic America and New Hampshire.

C. lagopodioides, Schk., distinct from the next.

C. cristata, Schweinitz, including *C. mirabilis*, Dewey,—filling three plates.

C. fœnea, Willd., also from New Granada,—filling three plates.

C. alata, Torr., figured from New York as well as Florida and Texan specimens.

C. adusta, Boott, including *C. argyrantha*, Tuckerman, and, as a northern variety, *C. pratensis*, Drejer,—illustrated by five plates! Carey's *C. adusta*, in Gray's Manual, Dr. Boott figures as a variety of *C. fœnea*.

C. straminea, Schk., with its varieties *tenera*, *aperta*, *festucacea*, *Crawei*, and *Meadii*,—six plates. The whole group, thus revised, will probably now be better understood than before.

C. stipata, Muhl., which comes also from Japan.

C. conjuncta, Boott, a new species, founded on the plant referred by Carey, in Gray's Manual, to *C. vulpina*, a plant of the Western States.

C. sparganioides, Muhl., with its variety *minor*.

C. cephaloidea, Dewey, at least in part, excluding the description in Wood's Botany.

C. cephalophora, Muhl., with *C. Leavenworthii*, Dewey, as a variety.

C. Muhlenbergii, Schk., and its variety *enervis*.

C. vulpinoidea, Michx., including *C. setacea* and *C. scabrior* of Dewey, "founded on immature specimens," *more suo*.

C. disticha, Huds., to which belongs *C. Sartwellii*, Dewey.

C. Gayana, Desv., a Chilian species, collected in New Mexico by Fendler (No. 881), and in the Rocky Mountains by Bourgeau.

It will be seen that this volume, illustrating some of our most troublesome species, will be particularly useful to North American botanists, who, with lively gratitude for what has been so generously done for them, indulge the earnest hope that the author's zeal and strength may enable him, *Deo favente*, to crown the whole with volume four. A. G.

5. *Thwaites, Enumeratio Plantarum Zeylaniæ, an Enumeration of Ceylon Plants, &c.*, Part III.—Although it has just reached us, this part bears the date of 1860. It comprises the *Monopetalæ*, excepting the *Rubiaceæ*, &c., which were in the second part. When finished we shall have a reliable and very convenient conspectus of the flora of Ceylon in a compact form. A. G.

6. *Annals of the Botanical Society of Canada:* Part III. From April, 1861, to February, 1862.—Contains the record of the general proceedings of this Society, as well as abstracts of some papers read, while others are printed *in extenso*. The contents are quite miscellaneous, many of the papers relating to culture or other practical subjects; and there are some local catalogues, &c. The society is evidently popular and flourishing, and is finding its way to its proper work. A. G.

7. *Bonapartea juncea* (Paxton's Bot. Dict.).—This rare and curious plant blossomed the last season at the Mount Hope Nurseries in this city. It belongs to the Pine Apple tribe, and was discovered in Peru, in 1800. It is one of the Bromeliaceæ, and was named, as above, in honor of Napoleon I. It has a large globose head just above the ground, covered with large scales closely compacted, from each of which arises a long, rush-like, four-sided and arching leaf more than a foot in length, presenting a very beautiful appearance. The intelligent proprietors of these nurseries, Messrs. Ellwanger & Barry, have reared this greenhouse plant for twenty-two years, but they do not know how old it was when purchased of Mr. Prince of Long Island, though then evidently not very young. Such had been its appearance for many years.

About the 10th of last September, from the summit of the globular head shot out a round tapering stem, near two inches in diameter, bearing small scales two to four inches apart and terminating in a small cuspidate point three inches long. The stem or scape grew rapidly, three or four inches a day, and once six inches, to the length of fifteen feet in less than sixty days. Three feet from the globular head there put forth a pair of flower-buds at each scale to the summit or through twelve feet, which soon began to blossom from the lowest in succession to the top. The flowers were yellowish or greenish-yellow, not striking, except for their great number. The pistil, six stamens, with versatile anthers, and the floral envelops of three inner and three outer parts, all stood on the ovary. The flowers did not come forth rapidly, so that the upper foot of them did not appear till February. On the lower part, the flowers rapidly decayed and fell off with the seed-vessel for six feet; but, on the plant being abundantly watered at the root, the flowers ceased to fall, and had the appearance of maturing some seeds. The plant was growing in an equably heated greenhouse. In the middle of March the plant was still maturing its seeds, though it is still doubtful whether any of them will be ripened, while it is certain that months must first intervene. There is no record of the flowering of this plant in the United States. An English nurseryman says he saw this species in flower in the garden of the Duke of Devonshire many years since. These few facts may be worthy of record in this Journal. C. D.

Rochester, March 25th, 1862.

8. *Acclimation encouraged in Australia.*—We have more than once had occasion to refer to the remarkable and well directed scientific activity which so honorably distinguishes the Australian colonies, and especially the colony of Victoria. To the Government Botanic Garden at Melbourne a Zoological Garden has been attached, and an Acclimatisation Society is coöperating in a practical direction. While Europe and America are making acquaintance with many a queer Australian beast or bird, or apparent combination of the two—like the *Ornithorhynchus*, our enterprising friends and neighbors at the antipodes are striving to stock their glades and streams with fish, flesh, and fowl from all lands, adapted to their fine climate, and subservient to use or ornament. Already, we believe, "the voice of the turtle is heard in their land," and the lark has become a denizen,—not to mention fowl of various kinds, of economical importance. As there is regular communication between New York and Boston and Melbourne, it may be well to publish here the following advertisement.

"*The Acclimatisation Society of Victoria, Australia*, are willing to make purchases of such useful or ornamental birds, animals, and fish landed in Melbourne, as may meet the requirements of the Society.

W. H. Archer, *Hon. Sec.*

"*The Argus Gold Prize Cup.*—The Argus gold prize cup, of the value of one hundred pounds, for the year 1861, will be given to any one (unconnected with *The Argus* or *Yeoman* newspapers) who, within the year ending 31st October, 1862, shall introduce into the colony the most valuable or interesting Animal, Bird, or Fish, in sufficient numbers to establish the breed. The decision to rest with the Council of the Acclimatisation Society, subject to the ratification of the Editor of *The Argus*. Application to be lodged with the Council of the Acclimatisation Society, before the 1st of December, 1862."

Zoology.—

9. *Uprising of the Seventeen-year Cicada, in New Haven County, Conn., in June*, 1860.—In June, 1843, swarms of the *Cicada septendecim*, Linn. (commonly called here the *Seventeen-year Locust,*) appeared in various places in New Haven County, Connecticut. Large numbers of this insect were then found in the bushes and trees on the eastern slope of West Rock, in the town of Hamden, about three miles N.N.W. from Yale College. On visiting this locality June 15, 1843, I found the insects active and noisy, and a record of my observations was made at the time. Seventeen years afterward, in the middle of June, 1860, I found this insect coming up in great numbers in and about the same spot, and one of the inhabitants of the vicinity assured me that the insect had not been seen there since 1843. The hoarse croaking noise made by an encampment of these insects can be heard a mile off, so that it is easy to detect them. In 1843 Judge Noyes Darling, who had spent most of his life near this place, told me that he could personally testify to an upcoming of this locust hereabouts in 1826, 1809 and 1792, and Rev. Jeremiah Day recently informed me that he had observed four of these periods here, viz: in 1809, 1826, 1843 and 1860.

It is remarkable that this insect, which exists but a few weeks in the perfect state above ground, should live nearly the whole of so long a life

in the earth as larva and pupa, and that in spite of varying weather, exposure and local causes, it should observe its seventeen-year period with such precision. It is also remarkable that in the United States there should be so many different districts each having its 17-year period of differing dates. It would seem much more probable that in any one place varying circumstances would hasten or retard the development of the insect, so that some individuals might be found there every year. To a very limited extent this may perhaps be the fact.

The locust-district to which New Haven County belongs extends from the Connecticut river westward to the Hudson river, and into New Jersey. That part of our State which lies east of Connecticut river has a different period. On the 22d of June, 1835, while travelling through Tolland County, Conn., in a stage coach, I passed through woods swarming with this Cicada. A map of the United States colored so as to show these different locust-districts would be of great interest to entomologists.

This insect is supposed to be peculiar to North America, and was made known to European naturalists by Peter Kalm of Sweden (*Kongl. Vetensk. Acad. Handl.* 1756), who travelled in Pennsylvania, New York, Canada, &c., in 1748 and 1749, and mentions an uprising of the Cicada about Philadelphia, Penn., in May, 1749, (*Travels, trans. by Forster, Lond.* 1772, 8°, 1 : 316, 2 : 62).

Very good accounts of this insect may be found in Prof. Nathaniel Potter's *Notes on the Locusta Septentrionalis Americanæ decem septima:* (Balt. 1839, 8vo, pp. 27, with plate;) and in Dr. T. W. Harris's Treatise on *Insects injurious to Vegetation*, (8vo. Bost., 1842, 1852, 1862).

New Haven, Conn., April 15, 1862. E. C. Herrick.

10. Thaddeus Wm. Harris, M.D. *A Treatise on some of the Insects injurious to Vegetation. A new edition, enlarged and improved, with additions from the Author's manuscripts, and original notes, and illustrated by engravings drawn from nature under the supervision of Prof.* Louis Agassiz. *Edited by* Charles L. Flint, *Secretary of the Massachusetts State Board of Agriculture.* Boston, 1862, 8vo, pp. xi and 640. With 8 engraved steel plates comprising 96 figures, besides 278 figures in wood. —The first edition of this excellent work of the late Dr. Harris of Cambridge, was published in 1841 (8vo. pp. 467) by the Legislature of the State of Massachusetts, as one of the Scientific Reports prepared at the public expense, a small issue of the same with slight changes being also printed for sale (Bost., 1842, 8vo, pp. 459). An enlarged edition of the same was published in 1852, (Bost., 1852, 8vo, pp. 521). These editions were without drawings of the insects described, and although the great merits of the work were from the first universally acknowledged, the want of illustrations lessened its usefulness. In 1859 the Legislature of Massachusetts directed Mr. Flint to prepare a new, enlarged and illustrated edition of Dr. Harris's work. Mr. Flint, availing himself of some of the best aid he could procure in this country, has executed his commission in a highly creditable manner; and the result is a beautiful and valuable volume of great practical usefulness to the horticulturist and the farmer. It is enriched by a large addition to the chapter on the butterflies from the author's own manuscripts, and by important notes contributed by Dr. John L. Leconte, Philip R. Uhler, Esq., Dr. John G.

Morris, Edward Norton, Esq., and Baron R. Osten Sacken. In this enterprise the State has expended over ten thousand dollars for 2500 copies for their own distribution. Besides this issue, the work appears in three other editions, one of 500 copies for the benefit of the family of Dr. Harris, in superb style on tinted paper with the steel plates colored, at $5 per copy, and two cheaper editions, at $3.50 and $2.50 each. It deserves to find an extensive sale.

A few of the insects described still lack illustrations, among which may be mentioned the *Angoumois grain moth* (p. 499)—the *Eurytoma Hordei* (553)—the *Cecidomyia culmicola* (582)—and the *wheat midge* (592), which at this time is one of our most destructive insects. In the cases of the *Aegeria exitiosa*, and the *Cecidomyia destructor*, a drawing of the female would have been more useful.

It would add much to the convenience of reference to give on the steel plates, under or near each figure, the Latin or English name of the insect represented, or at least the page of the book where the description may be found. H.

III. ASTRONOMY.

1. *Rediscovery of the Asteroid Calypso* (53).—The Asteroid Calypso (53) was discovered by Dr. Luther at Bilk, April 4, 1858. It appeared as a star of the eleventh magnitude, and continued to be observed at Berlin until the 17th of June. At the opposition in 1859 this asteroid was no where seen; and again at the opposition in 1860 it escaped detection, so that there was reason to apprehend that this body, like Daphne, was entirely lost. Dr. Luther therefore prepared an ephemeris from the most reliable elements, and after three weeks of laborious search, discovered on the 27th of January, 1862, a small planet, distant about one degree from the place computed for Calypso. Unfavorable weather prevented further observations until Feb. 6th, when he found it again, and proved that it was indeed Calypso. This planet has since been observed at several other observatories.

2. *Name for Asteroid* (59).—Asteroid (59) was discovered by Mr. Chacornac at the Observatory of Paris, on the 12th of September, 1860. According to established usage, it devolved upon Mr. Chacornac, or upon Mr. LeVerrier, the Director of the Observatory, to select a name for this planet. But LeVerrier declined giving this planet a name, on the ground that he wished to introduce a new nomenclature of the group of planets between Mars and Jupiter: and he suggested that without continuing to give each planet a particular name, it would be a sufficient distinction to mention the number in order of discovery, attaching thereto the name of the discoverer. Mr. J. R. Hind of London, to whom we owe the discovery of ten of these bodies, took decided ground against the proposed innovation, as leading inevitably to confusion and useless trouble; ultimately causing a return, by general consent, to our present nomenclature. The same ground was taken by Mr. Goldschmidt to whom we owe fourteen of these planets; and by Dr. Luther who has discovered eleven. The Astronomer Royal of England, Sir John Herschel, and Prof. Argelander, as well as astronomers very generally throughout Europe, also pronounced against the proposed innovation. After waiting for more than a year from the time of discovery, Dr. Weiss of the Vienna Obser-

vatory, who had taken particular charge of the observations of this planet, requested Prof. von Littrow, Director of the Vienna Observatory, to give the planet a name. Prof. von Littrow chose the name *Elpis*, in allusion to the political condition of Europe at the time of its discovery. This name was immediately accepted by the German astronomers. At length in January, 1862, Prof. LeVerrier announced that he no longer refused to allow Mr. Chacornac to select a name for this planet. Mr. Chacornac then requested Mr. Hind to assign a name, and Mr. Hind selected the name *Olympia*. This name has been accepted by the English astronomers, and will probably be universally adopted.

3. *Discovery of Asteroid* (73).—On the 8th of April, 1862, a planet of the 13th magnitude was discovered near the star Beta Virginis, by Mr. H. P. Tuttle of the Cambridge (Mass.) Observatory. It is the third which has been detected at this Observatory within the past year.

The name *Feronia* has been selected by Mr. Safford and Dr. Peters for the asteroid (72).

4. *Letter from the eminent astronomer, J. R. Hind of London, announcing the disappearance of a nebula.*—"Towards the close of the past year, it was announced by Prof. d'Arrest, of Copenhagen, that a nebula in the constellation Taurus, which was discovered at this observatory on the 11th of October, 1852, had totally vanished from its place in the heavens. That one of these objects, which the giant telescopes of the present day had taught us to regard as assemblages of stars in myriads at immense distances from the earth, should suddenly fade away, so as to be quite imperceptible in powerful instruments, must, I think, have been deemed a very improbable occurrence, even by many who are well acquainted with the care and experience of the observer by whom the statement was made. Within the last few days, however, Mr. LeVerrier has obtained so strong a confirmation of its accuracy, that there is no longer room for supposing it to have originated in one of those errors of observation which every practical astronomer knows will creep into his work in spite of all his precautions.

The nebula in question was situated in right ascension $4^h\ 13^m\ 54{\cdot}6$sec., and north declination $19°\ 11'\ 37''$, for the beginning of 1862. It was therefore about a degree and a half from the star Epsilon in Taurus, in the group commonly known as "the Hyades." Its diameter was about one minute of an arc, with a condensation of light in the centre; or its appearance was that of a distant globular cluster, when viewed in telescopes of insufficient power to resolve it into stars. From 1852 to 1856 a star of the 10th magnitude almost touched the edge of the nebula at its north-following edge; it was first remarked on the night the nebula was detected, having escaped notice on many occasions when its position had been under examination with the same telescope and powers. Hence I was induced to hint at its probable variability in a note upon the nebula published in No. 839 of the *Astronomische Nachrichten*. The suspicion is fully confirmed; the star has diminished to the twelfth magnitude, either simultaneously with, or soon after, the apparent extinction of the nebula.

The history of this object and the results of his observations on the night of January 26, are appended by Mr. LeVerrier to his Meteorological Bulletin of the 29th. The sky being very clear at intervals, the

Paris equatorial, which has an object-glass 12 French inches in diameter, was directed to the place of the nebula, but, notwithstanding stars of an extremely faint class were visible in its immediate neighborhood, not the slightest trace of it could be perceived either by M. LeVerrier or M. Chacornac. The star which Professor d'Arrest and I have repeatedly noted, of the tenth magnitude, and almost touching the nebula, had dwindled down to the twelfth; so that telescopes which would have shown it well between 1852 and 1856, would not at present afford a glimpse of it. From the fact that M. Chacornac saw the nebula in forming a chart of the stars in that region in 1854, and did not remark it while reconstructing the same in 1858 with a much more powerful instrument, there is reason to infer that the disappearance took place during 1856, or the following year.

How the variability of the nebula and a star closely adjacent is to be explained, it is not easy to say in the actual state of our knowledge of the constitution of the sidereal universe. A dense but invisible body of immense extent interposing between the earth and them might produce effects which would accord with those observed; yet it appears more natural to conclude that there is some intimate connexion between the star and the nebula, upon which alternations of visibility and invisibility of the latter may depend. If it be allowable to suppose that a nebula can shine by light reflected from a star, then the waning of the latter might account for apparent extinction of the former; but in this case it is hardly possible to conceive that the nebula can have a stellar constitution.

It is at least curious that several variable stars have been detected in the region of the great nebula in Orion; that in 1860 a star suddenly shone out in the middle of the well-known nebula Messier 80 (about half-way between Antares and Beta in Scorpio) which vanished in a few days; and that, as first remarked by Sir John Herschel, all the temporary stars, without exception, having been situate in or near to the borders of the Milky Way—the star-cluster or ring to which our system of sun and planets belongs. In the latter class are included the memorable star of B. C. 134, which led Hipparchus to form his catalogue of stars, and those which blazed forth in 1572 and 1604, in the times of Tycho Brahe and Kepler.

In concluding, I will venture to express the hope that some of the many amateur astronomers in this country who have provided themselves with telescopes of first-rate excellence, will keep a strict watch upon the remarkable pair of variables which I have briefly described in this communication. Continuity of observation is often most important, and can only be secured—and that not always in the uncertainty of weather —by a strong force of observers in different localities.

I am, Sir, your most obedient servant,

J. R. HIND.

Mr. Bishop's Observatory, Regent's Park, Feb. 3.

P. S. Since writing the above, I have received a letter from Professor Secchi, the able and energetic director of the Observatory of the Collegio Romano at Rome, by which it appears that in one of the proverbially clear skies of that city, and with the large telescope at his command, he was unable on the 27th ult., to discern the least vestige of the nebula."

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

From our Paris Correspondent.

1. *The Artesian Well at Passy.*—The complete success of the Artesian well at Passy has given lively satisfaction to all, and especially to those who appreciate the scientific interest which attaches to it. The question of water is of itself interesting enough to the Parisian people who have been reduced hitherto to the Seine as the principal source of potable water. The Prefect of the Seine had conceived a project for an aqueduct to be fed by the numerous springs in the neighborhood of Châlons sur Marne. It seems quite remarkable that this project was little to the public taste and that numerous voices were raised in favor of the river Seine! The Parisians are convinced that this river water is excellent; I will not affirm the contrary, but I am often struck with the complaints of strangers who generally charge upon this water the indispositions to which they are exposed during a visit in Paris. On the other hand I cannot maintain that in the long run an aqueduct is not the most economical provision for water for those who are prepared to meet the first cost. The example of Rome, which has been thus supplied even to the present day by the aqueducts of the Cæsars, proves this beyond dispute:—what would have been the expense during two thousand years of raising the water of the Tiber to a suitable height, if the Romans had been reduced to this method?

The city of Paris while awaiting the adoption of more thorough measures for attaining her water supply, has achieved an experiment which has given an excellent result, resolving several important questions and opening new ones. The first and most important question is to know if the water in a well of large dimensions will preserve an ascensional force sufficient to furnish a quantity of water proportioned to its increased diameter. Assuming that the water in the Passy well should rise with an abundance equal to that in the well of Grenelle, it ought to furnish near 40,000 cubic meters in 24 hours. (The cubic meter =220·17 gallons). Mr. Kind, the German engineer, the inventor of the method used in boring this well, and charged with the execution of the work, contracted to guarantee only 13,300 cubic meters, and on this estimate the plan was adopted. The boring commenced in September, 1854, and was finished on the 24th of September, 1861. The flow has remarkably exceeded the estimates—commencing slowly at first, on the 27th of last September it had reached 25,000 cubic meters and finally rested at 20,000 c. m. This yield, it is to be remembered, was found constant only at the well's mouth, and diminished very considerably when the tubes were added which carried it up to 25 meters above the ground. The well of Grenelle which yielded 2000 litres per minute at the surface, gave only 630 litres, less than one third, at the summit of a tube rising 33 metres above the level of the surface.

The second question is, what will be the influence of the new well upon the old, distant from it about 3000 metres (less than two miles). The latter soon commenced to show a diminished flow, and by the 1st of October the diminution had reached a fourth of the ordinary yield, falling from 630 to 460 litres per minute, a loss of about 40,000 gallons in

24 hours. The hope now is that there will be an increase again in the flow at Grenelle when the water of the Passy well by being raised considerably above the level of the earth shall again reëstablish the pressure. It appears impossible to foresee what may be the final result of this operation. Mr. Kind's method of boring perfectly met what was intended and the well had reached at the end of two years and three months 528 meters in depth, when a crush in the upper part seriously retarded the progress of the work. It required almost three years to repair this accident, and the total cost estimated by Mr. Kind at 350 thousand francs will reach near a million.

The water sheet is pierced 23 metres lower down than at the well of Grenelle—the latter being 547 metres absolute depth, and 511 m. below sea level; the well at Passy the orifice of which is $16^{m}\cdot 5$ higher has an actual depth of 588 m. or 533 m. beneath sea level. The temperature of the water is the same in both wells $=28°$ C. or $82°\cdot 4$ Fh.

It is easy to see that the third question—what advantage is it to make a new experiment of the same kind?—leaves an ample field for discussion. [We would say on this point that the experience of California has been decidedly adverse to the multiplication of Artesian wells, in the same hydrographical basin.—Eds.]

Dumas has given in the *Comptes Rendus* of the French Academy, (T. 53, p. 571) an interesting memoir in detail on this subject, from which most of the facts here presented are drawn.

2. *The Geological Society of France.*—This Society held its last annual reunion in Sept., 1861, at St.-Jean-de-Maurienne in Savoy, a province lately added to France. About sixty members were present at the meeting. The principal topic of discussion was the question which for thirty years has been controverted and sustained by Elie de Beaumont, viz: whether in the western Alps there exists an inversion, or a mixture, of the fauna and flora of the Lias with those of the Carboniferous formation. It is to be regretted that no one was present to sustain the thesis of the leading geologist of France, and still more that in so numerous a society there was no one to enter adequately into the detail of Alpine stratigraphy, a subject sufficiently difficult. The members were conducted over the ground of observation by Messrs Lory, Alf. Favre, the Abbé Chamoasset and Mr. Pillet.*

[The points of observation and argument are very nearly the same which have already been stated in detail in the review by Mr. Hunt of Prof. Favre's memoir on the structure of the Alps in vol. xxix, p. 118 of this Journal.—Eds.]

The number of the Bulletin of the Society containing the official notice of this meeting by the Secretaries is now in press.

3. *The Tunnel of Mt. Cenis.*—Your readers will find more interest probably in a notice of observations made during a recent visit to the famous Tunnel now in progress through Mt. Cenis, already more than once noticed in these pages.

This tunnel, the execution of which has been assumed by the Italian government, presents peculiar difficulties, especially because it is imposi-

* Prof. Favre has given a brief account of the observations made on this occasion in the Bib. Univ. de Geneve, Oct. 1861.

ble, owing to the enormous superincumbent mountain mass, to operate at more than two places. The mountain rises to the height of one thousand to fifteen hundred metres (3280 to 5000 feet, nearly) above the level of the gallery.

It was requisite from the first to find means to render the work as active as possible and employ machines for boring the blast holes. The little machine which moves the drills is ingeniously constructed but offers no difficulty to a mechanician. The percussion and rotation of the drill rod is accomplished by the power of compressed air which also injects a stream of water into the blast hole. In the trial made before the Geological Society of France which was conducted in one of the work shops of the company the drill entered a huge block of marble at the rate of 50 centimeters in 10 to 15 minutes, (about 1½ inches per minute). The feature of the process which interested us most was the production of the motive power. It is accomplished by an ingenious application of the hydraulic ram so much used in the United States, and set up here on a gigantic scale. The use of steam power presented great difficulties in a tunnel, each half of which when near its end will be over six kilometers long (=3¾ miles). They could not think of setting up boilers in the tunnel itself, since it was plain there would be serious difficulties in ventilation, and the attempt to conduct steam to so great a distance by pipes, would involve the loss of a great part of the power. By replacing steam with compressed air they enjoyed the double advantage of an economical application of the power at a distance from its source, and the use of the escaping air to renew the air of the tunnel. On the Italian side at Bardonèche, the air pumps are set up at about a kilometer from the opening of the tunnel, and they will act toward the last through nearly two leagues distance. The column of water which compresses the air in the chamber of the hydraulic ram is 25 metres high by 60 centimetres in diameter, the compression of air in the reservoir of the ram at the moment of fall is six atmospheres—at this instant a valve yielding at five atmospheres opens and a part of the compressed air escapes into immense boiler-like reservoirs. Five or six of these apparatus are needed for the regular progress of the work in the tunnel. The inventor of this remarkable apparatus, Mr. Tommelier, is director of the works. It is impossible to conceive any thing better adapted for a mountainous country where water is abundant. The apparatus appeared to us simple enough in its essential parts, which permitted the use of adequate solidity in the rest to resist the formidable shock with which it is shaken at short intervals. If the construction of these machines and the boring leaves little to desire it is by no means so sure that the perforation of the tunnel can be accelerated as much as would be presumed. They have perfected the rapidity of drilling, but the great labor of removing the rubbish is not accomplished more quickly than before. At the outset the engineers estimated six years, and to-day it seems probable that 12 years will be required to finish the tunnel if no unforeseen obstacles arise in the work.

4. *Spectroscope of Bunsen—Spectrology.*—The attention of the French scientific world is wholly fixed on *spectrology*, for thus do they designate the experiment with the spectroscope of Bunsen and Kirchhof. Mr. Grandeau, the pupil and fellow laborer of St. Clare Deville, has the merit

of having first initiated us into these beautiful researches, which he studied at Heidelberg whence he brought the first spectroscope seen in action in Paris. Since then it has become all the rage at Paris, and recently Mr. Jacmin has exhibited before a numerous auditory a large apparatus by Duboscq which projects the spectrum on a screen.

Mr. Grandeau has had the satisfaction of discovering the new metals, Cæsium and Rubidium, in the thermal waters of Bourbonne-les-Bains in larger quantities than in the waters examined by Bunsen. We might at first suppose that the discovery of new elements would be multiplied like those of the planets by a method at once so simple and certain. It does not appear at present however that this idea is likely to be realized. It is not sufficient, as seemed at first to be supposed, to expose a substance in the flame of the spectroscope to see defined there traces of all the elements it contains, while for those elements which like Cæsium and Rubidium exist in very minute quantity, it will always be found needful to separate first the larger part of the associated substances.

5. *The death of Biot*, is a great sorrow to all the friends of science. You have not wanted for biographical notices of this great savant. Permit me only to say what is on the lips of all:—that Biot is the most beautiful type known of what a scientist ought to be. He was wholly given up to science, and even to the last moment of his long life he was at its head. Three Academies of the *Institute* counted him among their members to prove that he belonged not alone to the physical sciences. But he was never any thing but the Professor and the Academician: he never subjected himself to the distractions of his illustrious cotemporary, Arago. Cuvier resembled him, with the advantage perhaps due to his vast erudition, and the clearness of his conceptions, but Cuvier did not see himself like Biot without a trace of the danger arising from the honors of high official station. Cuvier was made a baron, a peer of the realm, grand master of the University, and it is well known that he sometimes struggled against the power of jealousy.

6. *The two new Professors in the Garden of Plants.*—Messrs. Daubrée and d'Archiac opened their courses in the second week of March. Both the opening discourses resembled each other—first came an eulogy on their predecessors, followed by a profession of faith on their own part, and a programme of the courses they were commencing. These opening discourses, prepared with great care, drew together large audiences who rarely failed to find there matter for their legitimate applause.

Mr. Daubrée gave a masterly sketch of the history of geology, tracing its origin chiefly to the philosophers, Descartes and Leibnitz. He commenced his course, properly so-called, by the description of volcanic phenomena, and announced a complete exposition of Metamorphism, which will be taught now for the first time in the Garden of Plants. L. S.

Paris, April, 1862.

7. *Letter from Prof. Henry on the distribution of specimens in Natural History by the Smithsonian Institution.* (To the Editors of the American Journal of Science.)—GENTLEMEN:—In the letter of your Paris correspondent, published on page 149 of the January number of the Journal of Science for 1862, it is stated under the head of the Civic Museum of Milan, that the British Museum, and the Smithsonian Insti-

tution, were almost the only establishments that had not contributed materials towards the great work on serpents by Prof. Jan. As far as the Smithsonian Institution is concerned, this is an error, as its specimens have been freely at Prof. Jan's command. As full a series of North American serpents as could be supplied, amounting to about one hundred species was sent to him several years ago, and many additional species were transmitted last spring, leaving, according to Prof. Baird, but little to be desired as relates to North America. Indeed without the aid of the Smithsonian Institution, the species of serpents found in Texas, California, and other American localities, would have been inaccessible to Prof. Jan.

In this connection it may be stated that in the disposition of its undescribed materials, the Smithsonian Institution is governed solely by the desire to place them in the hands of naturalists best fitted to elaborate them without regard to individuals or country, and that it does not wait for an application, but itself makes the offer of the specimens. In addition to the free use by the best American naturalists, of such collections as they may need, its large series of Cephalopoda is now in the hands of Dr. Steenstrup of Copenhagen; its west coast shells is in the process of being described by Mr. P. P. Carpenter; its Polyzoa by Mr. Busk; its Hong Kong plants by Mr. Bentham, while types of the many new species described from its cabinet, amounting to more than ten thousand species and twenty thousand specimens, have been presented to most of the principal museums of the world.

I am, very respectfully your obed't servant,

JOSEPH HENRY, *Secretary S. I.*

Smithsonian Institution, Washington, Mar. 15, 1862.

8. *Ascent of Monte Rosa in Switzerland, September 4th,* 1861; by Rev. KINSLEY TWINING. (Extract from a private letter furnished by request to the Editors of this Journal.)— . . . . . But you are wondering, I presume, how we, who were lately on the other side of the mountains, have come into Italy. Our last was from Visp, where we were waiting for the cooler hours of the afternoon, and expecting then to go to St. Niklaus and thence to Zermatt. We carried out our plan successfully, and reached the inn on the Riffelberg Tuesday afternoon about 3 P. M. On the way we were joined by a young American from Boston who has travelled very largely. He had a desire equally strong with my own of climbing that terror of the Alps, Monte Rosa. Several ascents had been made this summer before we arrived. At Zermatt we saw three London young men who had made the attempt and gave it up only eight hundred or one thousand feet short of the summit, and we thought, after looking them over pretty carefully, that we were good for one thousand feet more than they. At the inn on the Riffelberg we met a young man who had achieved the ascent, and who told us so much about it that we determined to make the attempt the very next day if the weather should permit. We were fortunate in getting three of the very best Zermatt guides, and went to rest with our arrangements made and waiting to see what solution of the problem of the skies the morning would give.

Without describing what took place in those hours of delay, I still wish to interrupt my narrative at this point with an episode about Monte

Rosa. The great Italian mountain, in the estimate of most persons, is Mont Blanc of course. But Lord Byron never saw Monte Rosa, and though it is only a few feet lower than its great rival of Chamouni it never had any hymns sung in its praise till a few years ago. Indeed it had never been ascended to the very summit until the year 1855. I have read in some of the books on Monte Rosa that when De Saussure, that intrepid explorer of the Alps, was at Zermatt, he was unable to persuade the guide to ascend the last two peaks of this mountain and was compelled to abandon the attempt. The way up was at last found (as I think has been true in the case of nearly all the more difficult Alpine summits) not by a guide, but by a company of English travellers. I say the way was found by them, but this is not quite correct; for many persons before them had stood at the bottom of the Zumstein Spitze, eight hundred feet below the summit, and seen a way up which they had not the courage to attempt; and after having myself passed up that tremendous pathway of ice, I am perfectly convinced that, were the way untrodden, and could not the traveller be assured by knowing that others had found it practicable, he would turn away content at having surveyed the steps which lead to the inaccessible summit. This at least was the fate of every one who went alone to that spot and attempted to get higher,—and the Höchste Spitze, as it is called, was never made until six or seven persons, Englishmen and their guides, went to work together, and (tied together with a rope so that if one fell the others could save him) pushed along slowly and bravely to the very top. There they saw a grander view than Mont Blanc affords; and, though none of the difficulties of the ascent have been removed, a number of persons have followed them, each succeeding year, to the same grand height.

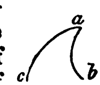
Murray, in comparing this with Mont Blanc, says there is no difficulty in the latter, and, comparing it with the ascent of Rigi—a mountain as difficult as Mount Washington—calls the latter a pleasant promenade. It may be so in the comparison, (and I think it is,) but in fact I can say, after walking up it, that to go up Rigi, even, is quite a trying thing in a hot day. But, difficult as Monte Rosa is, all who have made the ascent have agreed that the world has no other point of view to equal it. I will not now describe the scene which there opens to the eye, but merely say—what more than one Englishman has said to me after having ascended both Mont Blanc and Monte Rosa—"there is nothing to be seen from Mont Blanc, and it is foolish to make the ascent when Rosa is practicable."

To return from this digression: we were to start at 3 A. M. if the morning promised good weather. But at three the skies were doubtful, and we did not get off till a quarter of five. An Englishman who had himself made the ascent walked with us to the Görner glacier to enjoy the sunrise over Monte Rosa and the Lys Kamm,—which was indeed indescribably beautiful. The soft tint of morning fell upon the spotless snow and lay there till it brightened into the splendor of day. Behind us, at the end of the valley which contains the Görner glacier, and closing the view in that direction, rose the colossal stony pyramid of Monte Cervino, so steep that no snow adheres to its sides. Its inaccessible summit, four thousand feet above the snow from which it seems to rise, and nearly fifteen thou-

sand feet above the sea, caught also the first rays of morning and stood up in its many-colored magnificence, the only reminiscence among its snowy sisters of a world not covered with the glacier. One hour and ten minutes from the hotel brought us to the ice of the Görner glacier; forty minutes more took us across to the moraine on the other side, where the guides laid away a bottle of wine for the descent, and permitted us to take a drink of cold water. One hour more, up an icy hill about as steep as the lawn in front of the Hillhouse place, with deep crevasses opening on every side, brought us to our breakfast ground—a mass of broken rock, rising out of the glacier, and named "Auf der Platte." Here the guides brought out their stores of hard boiled eggs, bread, cheese, meat and wine. When these were eaten, or rather when as much was done in that direction as Kronig (the Grand Mogul of Monte Rosa) thought fit, the bags were shut, we were placed in line, and the rope (that signal that the time for hard work had come) was got out and all hands tied together in a line. King Kronig went first with his ice axe, to cut steps and hold on with the beak on the back of the axe; I next, three feet behind him; next Anton Rytz, a famous guide, with his face in a mask of checked cotton, who shouted "vorwärts" whenever Kronig cried "courage;" next came my friend Mr. ——, and last of all Franz Blatter, who sang "Ranz des vaches" all the way up, and who, if not strong enough to lift Monte Rosa itself, was abundantly able to carry any ordinary man to the top of it. Thus arranged we soon began to climb up the glacier, already quite steep (about 12°),—up, up, up, and ever up we went slowly and looking sharp where we stepped. First the surface was much like any ice that has been snowed upon and frozen again. Then we came into loose snow, three or four inches deep, which in its nature was a sort of compromise between hail and crystals. The path wound around from one ascent to another like a great serpent trailing between rounded hills of snow; what at one moment seemed like the crest of the ascent soon turned out the base of another, and where we discovered a level plain we were not permitted to go.

At first we walked a half hour together and then stopped for breath; but before long Kronig complained that we stopped every fifteen minutes; and after a while he declared that if we had our way it would be fifteen minutes walking and fifteen minutes on our backs on the snow—and then it would be all up for the Höchste Spitze. In the midst of these dismal forebodings I heard a heavy fall and the call of the guides behind, "attendez." I looked around. Blatter was rushing furiously down hill—for what, did not appear. But I soon saw that Mr. —— had fallen down exhausted and let his alpenstock go where he himself would have gone had not the strong arms of Tony Rytz been on him, and a good twist of the rope around him. His face was pale, his lips blue, and Kronig whispered to me in German, that it was impossible for him to reach the summit. However he rallied and went on very well. After three hours of such painful drudgery we reached the foot of the Signal Kuppe, where the guides took off their knapsacks—all hands had some new refreshment for the last great labor—the rope was doubled around us—and then Kronig set out ahead, cutting zig-zags in the fearful dome of ice we had to climb. In the earlier part of the morning I had looked

around a good deal on the scenery; but as we went higher and the labor became greater, I could not afford to throw away strength enough to look around; and now in this spot my horizon was restricted to the three feet square which lay under my eyes. After a long time of zigzagging up and back, around a dome of ice so steep that it would be impossible to stand on it anywhere without having places cut for the feet, we surmounted the Signal Kuppe dome, and stood at the base of the peak of terror—the Zumstein—where, even now, fully one-half of the few who come to it turn back. Here we looked back upon the ice wall we had edged around, step by step, putting our toes in holes cut in the ice, and saw that though it was at an angle of nearly forty-five degrees it was nothing in comparison to the eight hundred feet which remained. There were still two peaks above us which rose like crests one behind the other and in the same line—sharp, like a hatchet, and accessible only over what may be called the *blade* of ice which formed the ridge. It is a fact that the path here was a scant foot in width,—on the right was an abrupt precipice three or four thousand feet in depth,—on the left an almost equally steep declivity. Up this comb of ice Kronig cut steps and shouted "courage" with stirring drum-like voice, while Blatter, every few minutes, sang "Ranz des vaches" for our amusement. The excitement of such an ascent and of the scene around and before was so great that I felt no fatigue, and marched up as easily as if it were over a stairway. After proceeding thus some twenty minutes, I learned by accident the meaning of something which had been unintelligible to me in descriptions I had heard of this part of the ascent. It happened that, in striking my alpenstock into the ice for a good hold, it seemed once to go through; and when I drew it up to see what was the matter, there was a little round hole punched through the ice under my feet, through which I could look down several thousand feet along the face of a greenish-blue icy precipice. If I did not comprehend at the moment the full meaning of this observation, I did an instant later, when I came upon a larger hole through which I could see at leisure how the mountain was constructed, and in particular what sort of support our path had. The case, as I understand it, is that this ice has filled in the hollow between one peak and the other, and while it is banked out in a steep declivity toward the north, on the south it is built up straight above the precipitous rocks, and even overhangs them, as is often the case in a drift of snow. Hence it happens that the only place possible for an ascent is the icy path overhanging the tremendous gulf I have described. We went up without any slip against a boisterous wind, and after a hard struggle with the rocks reached the bottom of the Höchste Spitze. A section through the middle of the Zumstein Spitze would give some such diagram as this: *a b* being the south face of the precipice, *a c* the rounded or banked up glacier on the north, and *a* the place of the path up the edge of the crest. On reaching the summit of the Zumstein we rested on the warm side of the rocks, then worked our way down a hard descent of fifty feet, and there found ourselves at the bottom of the Höchste Spitze. It is more steep than the Zumstein, but not as dangerous; for the path lies back two or three feet from the edge of the snow and ice. When this crest was surmounted we stood on the



Höchste Spitze, but not on its highest point. These mountains are a kind of slate which breaks up easily into large and small blocks; and where the summit is a thin blade of stone, like Monte Rosa, it is not one piece of rock, but more like a wall loosely put together and broken down. I fancy that once this whole peak was one narrow wall of rock, eight or ten rods long, running east and west, and highest toward the east. The action of frost and weather and other natural forces broke it up into blocks, and in the process of time cut a breach through the middle, leaving it as we found it, a double or forked peak with the shorter tine first, or toward the west.

To give some idea of the difficulty of crossing this little gap and actually getting upon the opposite and highest point, I will say that, although it is not thirty feet deep nor twenty feet broad, still the two German brothers Schlagintweit, who were certainly brave men and most intrepid explorers, and who had nerve enough to mount, first of all who have attempted it, on to the lower tine of the summit, gave up the other. It was not the muscular exertion which deterred them, nor the time likely to be occupied in crossing the gap; for I passed straight through it at a burst, and was on the topmost point in two or three minutes afterwards. But it must have been the dreadful unknown task of venturing out over that airy walk and on to that apparently unsupported summit, where no previous foot had been, and whose accessibility they could not prove beforehand and could scarcely believe when looking upon it. It was a far different thing for us to do. I knew that the path was firm and that we could all sit on the summit, though only one at a time could mount the sharp point which caps it. I knew that there was no great labor in the undertaking, and no danger if my head was steady and my courage good. All this made it a perfectly easy thing for me to do, and I so forgot both difficulty and danger and the descent, that the hour we spent on that stony point, 15,223 feet above the sea, was one of the most delightful in all my life. Around us on every side were great mountains sunk down beneath their snows, like abashed virgins drooping in reverence; north, east and west, a panorama of majestic mountains lay around us. The dark needle of the Finster Aarhorn rose out of the snows of the great glacier of the Aar,—Schreckhorn, Wetterhorn, Titlis, the Eiger, and the Sidelhorn stood around it like an ancient brotherhood of giants. The Bernese Alps drew out their line in equal beauty and majesty from the Angelhörner and the Wetterhorn till it seemed to run up into the skies from the Silberhorn and the Jungfrau. Nearly due west lay the immense mass of Mont Blanc, white and glistening,—the one summit over which the eye could not range. The space between was filled with whatever of lake or mountain, of valley, field or barren, moor there is in Switzerland—lonely snowy points rising one above the other—dark black-ribbed glaciers rolling into the valleys—here a dome of snow capping the mountain with a biscuit-like cover of the purest white—while, all around the broken edges, blue avalanches were ready to drop into the grey and hazy depths beneath them. Southward, the eye looked through a bright blue sky into Italy,—first over the Pennine Alps, resting for a moment with admiration upon that most grand and pleasing object, the Becca di Nona: then in swift flight it passed from the thousand peaks and vales of Piedmont to Lago

Como and Maggiore,—and thence ran straight out into the plains of Lombardy and Venetia. How can I ever describe what my eyes saw in this view. I stood there drinking it in with delight—I knew not how long. I bade myself remember this and remember that; but, now, what can I recall. Becca di Nona is a distinct form in my mind, but beside this all is a formless procession of beautiful images—a delightful memory of evanescent things whose shape I do not know that I ever saw, and with respect to which I am certainly unable to say at this moment of what they consist. I remember a light falling down upon Italy, blue, soft, and yet so distinct and clear that all I saw against the sky had an edge—but it was an edge of velvet. I remember how my eye, accustomed to the altitudes of the Alps, at first refused to rest upon the blue plains of Italy, but adjusted itself to them as clouds in the air, till at length after something like a struggle it took the right focus, and falling down to the level of the sea, made me conscious of my own great elevation.

It is impossible to describe the light which illuminated the Italian view. It was a substance—as it seemed—and a color; and yet it was soft and clear. It glowed without being hazy, and gave everything with great distinctness without letting the eye into the deformities of the country, or displaying the formless and less pleasing secrets of the landscape, as the midday sun of Switzerland does. The guides said that in perfect weather the spires of the cathedral at Milan are visible, and that the eye can reach nearly as far as Venice. There were clouds on our horizon, and some of the valleys were filled with their billowy masses. The wind tossed them about like balloons, and as they rose and fell and tumbled about on the unstable support of the air (as it seemed to be), and as at times they dissolved or broke apart, we had lovely views of the country below.

My companion reached the summit a few minutes after I did, but immediately fell asleep and could not be roused till a few minutes before we left the top. I really did not observe how he came up the Zumstein or the crest of the Höchste Spitze, but I well remember seeing him lying flat on the lower tine of the summit, whence the guides steadied and lifted him up till he was on the top; when he did precisely what Albert Smith did on Mont Blanc, i. e., went to sleep. I made a number of observations upon myself, and could not see that the great altitude changed my bodily condition in any way. I was not sick at the stomach at all—my breath was neither shorter nor deeper as I could perceive—my head was not at all infirm. Hearing was equally good, as I can testify after having been bothered with Blatter's incessant "Ranz des vaches." The air filled my lungs as it does elsewhere, and from observing myself I could detect none of those signs of a great altitude which other persons have felt on the summits of such high mountains. On Faulhorn, and at other times when I have been on high mountains, I have noticed the darkness of the sky, and was prepared to find the vault of a deep and almost blackish blue on Rosa. But in this I was disappointed; and I do not know to what I am to attribute its ordinary appearance unless to the slight haze which, as it were, detained the eye in an illuminated atmosphere, and prevented it from looking into the thin, clear and rayless space which so many observers have described as the dark vault seen from the summits of high mountains. I have an indistinct recollection of having felt cold, and am

certain that the guides said they were, and that it would not do to remain longer in such a wind. What the temperature was I do not know, although there was a minimum thermometer there which had been placed by the Alpine Club. But I could not make out anything from it because the indicating fluid was perfectly colorless and seemed to have faded out, so that it was impossible to see where the column stood. At last we commenced the descent, at 1 o'clock P.M.; but first I went up the pinnacle once more and waved my adieus from it to the silent world of majesty and beauty which in an hour of time had given me so much pleasure. In the silence of those solitudes my voice was lost,—nothing that we could do seemed able to disturb it. The wind, which blew in tremendous gusts and then subsided, was the only sound which filled those spaces, except when the avalanche (of which there were many during our ascent) added its thunder to the roar of the tempest, or sliding down amid the silent snows grew into a sound which waved through the air and made the mountains tremble.

But this is not the descent. I confess I was more nervous about going down than I had been at any time in going up. One hour was consumed in the first eight hundred feet—then soon after we came to the dome up which our zigzags ran and which we had climbed so slowly in the morning with our faces to the wall and our toes in holes in the ice—edging our way along, a step at a time. Soon we saw, below, the knapsacks of the guides where they left them, with the bottle of champagne and other refreshments they had brought up and deposited there where the labor and danger of the ascent both begin and end,—to celebrate with them our victory, when we had come once more into safe places. Four hundred or five hundred feet above this spot the leading guide, John Kronig, sat down on the snow; and while I was wondering what was to happen, Mr. —— was got into place behind him, his feet put forward under the guide's arms,—then the second guide followed. I instinctively took my place, supposing it would be quite right, but rather hoping we were not going to slide down that tremendous declivity at the risk of our pantaloons. However, the sun, which was cold on the top, was warmer here, and the loose snow was soft to a depth of three or four inches, and the guides meant to improve it; so when all was ready Blatter sat down behind me, and off went the five like a kind of human sled. The guides' alpenstocks, managed by their strong and skillful arms, kept us in line, and, I suppose, lessened the speed somewhat. But they had, after all, so little power against the force of gravity that we shot down like an arrow and ploughed into the snow opposite our camp—all wanting to laugh and shout, but utterly without the breath required in such exercises.

When we were on our feet again the lunch came out and we had a merry time in consuming it. The guides danced and rolled about on the snow, and sang rattling French songs with a perfect *abandon*, as if delighted to have come down Monte Rosa once more alive. We were still a great way from the hotel—not less than eighteen miles. The guides said it could not be done in less than three hours, and we made up our minds to see if we could accomplish it in that time. The rope which had been taken off at lunch came out again, and we were all tied

together once more in a line:—and now the problem was to slide down in one hour the glacier which had cost us five in the morning. We stood up straight, and steered with our alpenstocks; the strong arms of the guides served for rudders, stays and breaks; and down we went at a tremendous speed. Do not think, however, it was mere sport. My legs would now and then tremble under the exertion to keep them in place, my breath would give out, and after fifteen minutes of such rapid descent we would have to lie down and get ready to try it again. The steep places were passed sled-wise. The ladies had gone up to the top of Görner Grat about 1 o'clock, P. M., to watch our progress, and there, beside having one of the finest views in Switzerland to enjoy, had the full sight of our novel method of descent. Some gentlemen were with them who had made the ascent themselves and were able to show them where to point their glass in order to find the exceedingly small black specks they were looking for. At last these were discovered refreshing themselves at the bottom of the dangerous peaks, and then sliding down hill at an unheard of rate; and finally they disappeared among the rocks in the moraine of the glacier, when they were lost for the time, and not again seen till they appeared at the hotel, some two hours from the place.—I believe the distance up and down is rated at forty miles. We were absent from the hotel thirteen hours and a quarter; of which three hours and a half were consumed in the halt on the summit and those for breakfast and the other lunches up and down.

9. *Geological and Mineralogical Museum at Rochester, N. Y.*—Having lately enjoyed an opportunity of inspecting the collection of fossils, rocks and minerals formed by Prof. Henry A. Ward, of Rochester, a short notice of it will be acceptable as marking the steady progress making in the appreciation of scientific objects in the United States. This collection has been amassed by the personal exertions and zeal of Prof. Ward during six years passed by him in all parts of Europe, in Asia, Africa and America, he having travelled over 100,000 miles in his visits to localities and collections. It has been formed from the first on a plan designed to illustrate the departments of geology and mineralogy to students. This plan contemplated the representation of every genus of fossil organism hitherto described, as well as a complete lithological and mineralogical collection. Happily for science, Prof. Ward's plans found a liberal patron in the noble liberality of the Hon. LEVI WARD, a wealthy citizen of Rochester, who advanced the funds required for the purpose to an extent of nearly twenty thousand dollars. These collections are temporarily arranged in a large hall (80 by 120 feet and 20 feet high) in Rochester, with several smaller rooms attached. The general effect is magnificent and imposing. On first entering the Hall, the eye is arrested by the gigantic head of the Deinotherium (cast) and other huge forms of fossil life, by the long ranges of polished marbles, Septaria, Ammonites, &c., which although not yet systematically arranged in detail, are conspicuous objects in the *coup d'œil*. It is difficult from statistical statements to form any adequate impression of such a collection. A few figures will however assist in a comparison.

The Minerals are arranged according to Dana's last edition: 5,200 specimens are conspicuously placed on isolated blocks and nicely labelled.

The Rocks (numbering 3000 specimens) are classified according to mineral composition independent of structure or geological position—a strictly lithological collection. The individual pieces are large, well formed, and whenever needed to show structure or economical value, polished blocks of the same rocks stand beside their rough associates. A complete series of Cordier's species of rocks labelled by himself is merged in this lithological collection. In examining this collection one is constantly struck with the number of authentic specimens collected by Prof. Ward from the localities where specific rocks were first described, e. g., Syenites from Syena, Dolomite from Fassathal, Palagonite from Palagonia, &c.

In addition to the lithological collection is another of some 700 specimens arranged statigraphically and designed to precede the fossils in each geological formation. Of special collections we noticed a beautiful suite of 350 polished blocks of Italian marbles and ornamental stones selected and arranged by Prof. Meneghini of Pisa: a series of 180 Tuscan rocks; of 100 from Monte Bolca; 120 from the Paris Basin; 80 from Saxony; 60 from Lake Superior; and 200 from Central France. There is also a superior special collection from Mt. Vesuvius, selected from d'Archiac's cabinet. Thus the total of rock specimens reaches about 5000, each well mounted and labelled. The whole is arranged on the system of Cordier, with whom Prof. Ward was a diligent student.

It is difficult to form an estimate of the extent and value of a Palæontological collection by a statement of numerical quantities. It is probably safe to state that Prof. Ward's collection contains 8,000 distinct species of fossils from European localities represented by 25,000 specimens, besides the collection of fossils from American localities. Some of the genera we noticed as particularly rich in species. Thus there are about 540 species of *Ammonites*, 100 species of *Echinoderms*, 150 species of *Trilobites*. When completely arranged it is believed that this collection will require about 40,000 labels.

Unique specimens are represented by casts in which Prof. Ward's collection is peculiarly rich, embracing, if the *Trilobites* and *Foraminiferæ* are included, over 200 genera.

Thus the famous Mosasaurus Hoffmanni from the Garden of Plants, Cuvier's Maestricht specimen, never before allowed to be copied, is now available to American collections: Prof. Ward having the moulds for reproducing this and a large number of other celebrated and unique specimens, like the head of Deinotherium. We have received the following note from Prof. Hitchcock in reference to the cast of Deinotherium which has been recently added to the Museum at Amherst, as well as to Prof. Ward's collection.

From Prof. E. Hitchcock, Senior.

"A fine plaster cast of the head of a Deinotherium of the natural size, has just been added to the cabinet of Amherst College. As this is the first cast of this unique specimen ever prepared in this country, I have thought that you might like a brief notice of it. It was executed in Rochester, N. Y., under the direction of Prof. Henry A. Ward, of the University in that place, from a copy recently received by him from Germany, and is done very skillfully and perfectly. It makes a very strong impression on the beholder. One sees that this animal must have been the largest of all terrestrial quadrupeds yet discovered, if indeed it was such, and that the power of the curved tusks in his lower

jaw, must have been enormous in grubbing up roots. The huge nasal fossæ are, also, apparently, a striking proof of the existence in the living animal of a huge proboscis, such as is usually figured. Pictet and others, as you know, place this animal among the Sirenoids.

Mr. Ward expects to receive and to copy, also, in a few weeks, a cast of the femur of the Deinotherium, five feet long, as well as some other bones; and a head reduced in size. The cost of the cast which we have received, with a platform and irons for mounting, is *one hundred and twenty dollars*, and it has been presented to the College by myself and Ephraim Brown, Esq., of Lowell.

I do not remember to have seen in your Journal any description of the splendid cabinet which Professor Ward has collected, now on exhibition in Rochester. By incredible industry, and visiting almost every important locality in Europe, and many in Asia and Africa, as well as in this country, and expending much money, he has brought together a geological cabinet unequalled as a whole in the United States; also a very large collectiou of simple minerals. It might well satisfy an octogenarian naturalist as his life work; but Prof. Ward, I understand, is not yet thirty. It will well repay the scientific man for turning aside a good distance to visit it.

Neither do I remember to have seen it any where stated in print, that Prof. Ward has had copied in plaster almost all the large and rare geological specimens in the cabinets of Europe, which are sold in such establishments as those of Krantz at Bonn. These are fully equal in execution to those from Bonn, and considerably cheaper, to say nothing of transportation.

I am very glad that Prof. Ward is able and willing to superintend this work, which will be of so great service to the literary institutions of our country. He will soon be able to furnish casts of 200 genera, great and small. I have obtained as many of them as my means would allow, and have seen most of them, and know that they are very satisfactory. I hope Prof. Ward will soon publish a catalogue, with prices, of such as his moulders can furnish."

We understand that an effort is on foot to secure this fine museum for the city of Rochester. It is an object well worthy of the ambition of any city to obtain such a noble and permanent institution, free at all times to the public. The power of such a collection is immense in raising the public taste to an enlightened standard, proving that there are other objects worth attention besides those which minister to sensuous pleasure. It is justly esteemed as an evidence of a refined and cultivated community when collections of art and museums of natural history are established and opened at the public expense. The citizens of Rochester, if they secure the permanent establishment of the Ward Museum in their city, may well pride themselves on the acquisition: they will hold the most extensive geological museum in the United States and secure the presence of students in geology and mineralogy, who will come up to Rochester to avail themselves of the educational advantages connected with this museum, and the lectures of Prof. Ward, who now holds the chair of natural science in the University of Rochester.

10. *Fossil larve in the Connecticut River Sandstone.*—One of the most interesting objects described and figured in the great work of Prof. Hitchcock on the footprints of the Connecticut River sandstone is the larve of a Neuropterous insect. In a recent letter, Dr. John L. Leconte has given the following opinion respecting the relations of the species:

"The animal figured on p. 8 of Ichnology of Massachusetts, appears to me to resemble most a larva of a Neuropterous insect belonging to the family *Ephemeridae.* The projections each side look to me like the branchiæ proceeding from the abdominal segments as seen in the larvæ of Ephemera."

Prof. Hitchcock has expressed his desire to the writer, in view of the above opinion, that the name of the species be changed to *Palephemera mediæva.* J. D. Dana.

11. *On the Geology and Natural History of the Upper Missouri;* being the substance of a report made to Lieut. G. K. Warren, T.E., U.S.A., by Dr. F. V. Hayden, Surgeon and Geologist of the expedition to the Upper Missouri and Yellow Stone, under the command of Lieut. Warren. 228 pages, 4to, with a Geological Map. From the Transactions of the American Philosophical Society.—It being probable, from circumstances beyond control, that the publication of Lieut. Warren's final report would be long delayed, permission was obtained to abstract such parts of the Geology and Natural History portions as were deemed desirable for publication in a connected form. These constitute a report of progress rather than a complete work on that portion of the West. The contents of the memoir are as follows:

Historical Introduction.
Part I.—Descriptive geology of the routes.
Chapter I.—Exploration of Platte River Valley from Bellevue to the mouth of Elkhorn river.
Chapter 2.—From Bellevue to the Big Sioux river.
" 3.—From Omaha City to Fort Laramie.
" 4.—Geology in the vicinity of Fort Laramie.
" 5.—Fort Laramie to the Black Hills.
" 6.—From Bear Peak to Fort Randall on the Missouri river.
Part II.—General geology of the country.
Chapter 7.—Granite, Stratified Azoic, and Eruptive rocks.
" 8.—Potsdam Sandstone, (Lower Silurian).
" 9.—Carboniferous and Permian periods.
" 10.—Jurassic System.
" 11.—Tertiary Basins of the Upper Missouri.
" 12.—Quaternary deposits.
" 13.—Resumé of the Geology of the Missouri river and its tributaries.
" 14.—Catalogue of Minerals and Geological specimens.
Part III.—Zoology and Botany.
Chapter 15.—Catalogue of Minerals with notes on their habits and distribution, 48 species.
Chapter 16.—Catalogue of Birds with notes on their geographical distribution, 256 species.
Chapter 17.—Catalogue of Reptiles, Fishes and recent shells. Reptiles, 33 species; Fishes, 25 species; Recent Mollusca, 65 species.
Chapter 18.—Catalogue of recent plants. Phænogamous plants, 726 species; Carices, 56 species.

Dr. Hayden is a devoted worker in several departments of investigation not usually united in one person. He is now engaged upon some ethnographical and philological researches related to the aboriginal tribes among whom he has resided. Some of the results of these studies we hope to present to our readers in an early number.

12. *Sixth Annual Report of the Secretary of the Maine Board of Agriculture;* embracing also the Reports on the Scientific Survey, 1861. Augusta: Stevens & Sayward, Printers to the State. 8vo, pp. 464.—The larger portion of this volume is devoted to the "Preliminary Report upon the Natural History and Geology of the State of Maine," under the direction of Ezekiel Holmes, of Winthrop, *Naturalist*, and Charles H. Hitchcock, of Amherst, Mass., *Geologist*, assisted by Geo. L. Goodale,

of Saco, *Botanist* and *Chemist*, J. C. Houghton, of Still River, Mass., *Mineralogist*, A. S. Packard, Jr., of Brunswick, *Entomologist*, and C. B. Fuller, of Portland, *Marine Zoologist.*

We must defer to a subsequent issue a notice of this Report, which embraces some points of general geology of great scientific interest: as for example, the proof that the lowest member of the Carboniferous system in New Brunswick overlies unconformably the equivalents of the Perry beds, establishing, in view of Mr. Hitchcock, the certainty that the Carboniferous system does not occur in Maine.

It is worthy of remark that, in these times of civil strife, Maine has the courage to inaugurate a new scientific survey, while some other States are suspending work on surveys only partly completed. This is the more to the honor of Maine, inasmuch as in case of a foreign war she would be the first to suffer the liability of invasion.

13. *Report on the Geological Survey of the State of Wisconsin*, Vol. I.; by James Hall on General Geology and Palæontology, and J. D. Whitney on the Upper Mississippi Lead Region. Printed by authority of the Legislature of Wisconsin, January, 1862. Large 8vo, pp. 455.—This very valuable volume contains a chapter in 72 pages on the Physical Geography and General Geology of the State of Wisconsin, by Prof. Hall, followed by a Report on the Lead Region, filling 350 pages in five chapters by Prof. Whitney. This report is of the highest economic and general interest, presenting the whole subject of the lead region in its historical, physical, geological, mineralogical and mining relations in a methodical and exhaustive style, leaving nothing to desire. The report is concluded by some observations on the mammalian remains found in the lead crevices by Profs. Leidy and Wyman; and the last chapter contains a catalogue of fossils, with remarks and descriptions of some new ones by Prof. Hall. We shall revert to this report again in more detail. It is admirably well printed and illustrated. The beautiful maps, diagrams and sections by Prof. Whitney of the lead region deserve especial mention.

14. Obituary.—*Hiram A. Prout, M.D.* died at St. Louis, Mo., April 21, 1862. Dr. Prout was well known as a naturalist and a zealous member of the St. Louis Academy of Science. Our geological readers will recall his description, in March, 1847, (this Jour., iii, 248) of a fossil maxillary bone of Palæotherium from near White River in the Mauvaise Terres. This was our first definite knowledge of that vast mausoleum of Palæotherial remains, since become so famous. He was an eminent physician and most useful citizen.

K. C. v. Leonhard.—Died on the 23d of January, 1862, at Heidelberg, K. C. v. Leonhard, Prof. of Mineralogy in that city since 1818. He was born in Rumpenheim near Hanau, Sept. 12, 1779. Among his numerous writings the following deserve mention:

Handbuch einer allgemeinen topographischen Mineralogie. 3 Bde. Frankfort, 1809.—Characteristik der Felsarten. Heidelberg, 1823.—Handbuch der Oryktognosie. Heidelberg, 1826. 2 Aufl.—Die Basalt Gebilde. 2 Bde. Stuttgart, 1832.—Grundzüge der Oryktognosie. Heidelberg, 1833. 2 Aufl.—Agenda geognostica. Heidelberg, 1838. 2 Aufl.—Grundzüge der Geologie und Geognosie. Heidelberg, 1839. 3 Aufl.—Geologie oder Naturgeschichte der Erde. 5 Bde. Stuttgart, 1836–1844.—Lehrbuch der Geognosie und Geologie. Stuttgart, 1849. 2 Aufl.

Taschenbuch für die gesammte Mineralogie. Frankfort, 1807–1824.—Zeitschrift für Mineralogie. Frankfort, 1825–1829.—Jahrbuch für Mineralogie etc. von K. C. v. Leonhard und H. G. Bronn. Stuttgart, 1830–1862.

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[*From the* QUARTERLY JOURNAL *of the* GEOLOGICAL SOCIETY *for August* 1864.]

With the respect of the Author

ON

MISSING SEDIMENTARY FORMATIONS,

FROM

SUSPENSION OR REMOVAL

OF

DEPOSITS.

BY

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Contents.

I. Introduction.

Although it has been long known that formations or parts of formations are frequently absent from their places* in the vertical series of sedimentary rocks, little notice has been hitherto taken of this absence, except in single unconnected cases; and that little consists almost entirely of a few remarks in Mr. Jukes's excellent 'Manual' and an allusion or two in the writings of Sir R. I. Murchison, Mr. Darwin, and Prof. J. Hall, of New York.

As circumstances, relations, processes, and purposes well worthy of our attention are here concerned, it is proposed now to open out and examine this subject as well as it can be done in a first attempt.

The progress of geological knowledge, as of all science, is usually

* As Lias from between Oolite and Trias; Upper Silurian from between Devonian and Lower Silurian: the roof being the upper, and the floor the lower side of the place which the missing rock should have occupied; thus occasioning a blank.

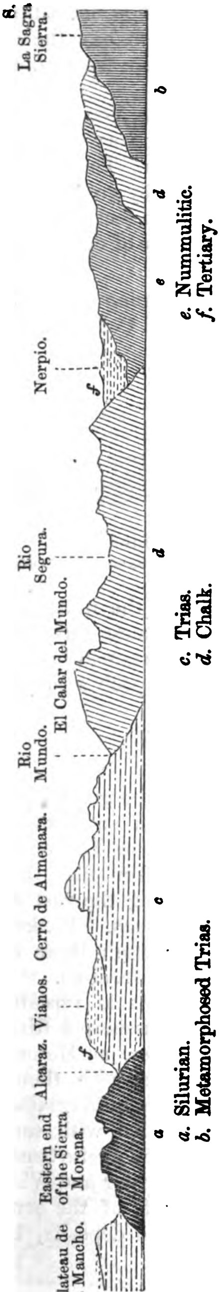


Fig. 1.—*Diagram-section from the Eastern end of the Sierra Morena to the Sagra Sierra* (after MM. de Verneuil and Collomb).

by steps. The general idea of any advance arrives first, and may perhaps lie dormant for years, when follows its development by another workman, and perhaps in another country; just as Vicomte d'Archiac, in 1848, sketched in unmistakeable language the principal features of the great Terripetal Theory, which Bronn, in 1862, made his own by the most masterly elaboration,—Ami Boué, in 1852, having prepared the way by an elaborate article in the 'Bulletin de la Société Géologique de France,' 2nd series, vol. ix. p. 437. While in their vertical order of succession the sedimentary rocks never vary, unless disturbed, they differ greatly in thickness and extent—far stretching out and thin in plains, thick and limited in area among mountains, as we see abundantly verified in the Americas, India, Russia, &c. But they have also been from the very earliest periods largely, and frequently, absent from their normal situations, and much more so than appears in systematic works; and it is easy to see, from the vast and universal prevalence of these suspensions and removals of deposits, that it will be one day proved that the emerged tracts were at all periods so extensive and so united as to constitute from one-fifth to one-third of the whole surface of the globe.

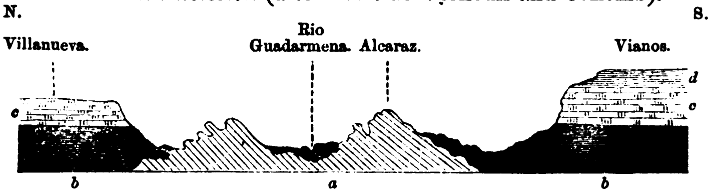
While any given district was in a state of emergence, various sediments were being deposited in the neighbouring sea, which was at the same time tenanted by a fauna so balanced and harmonized that the individuals could thrive and follow the promptings of their instincts—whole races dying out, we may safely suppose. Now, if only one such epoch commence, become mature, and decline, we see that the raised land must have remained as such for an immensely long period. What then must have been the length of that period of time during which an emerged tract remained through ten or twenty epochs above water, as has frequently occurred?* Missing formations, then, hold a high and important place as a result of one of the constructive processes of

* Canada, Hudson's Bay, Germany, &c. &c.

the earth's crust; and the work is still going on. It is not a thing of the past only; but the ocean-bottom, parcelled out like the dry land into geological districts, is still receiving accessions from animal débris and insoluble matter suspended in its waters.

The Sections, Figs. 1 & 2, I owe to Messrs. De Verneuil and Collomb; and they form one of the results of their very extensive and methodical investigation into the geology of Spain. They exhibit the structure of a region, 150 miles long, overspread by great blanks, which, for our purpose, is sufficiently explained by the sections themselves, which are placed here in proof of the importance of our subject.

Fig. 2.—*Section of the Sierra Morena (Spain), showing two great Blanks in succession* (after MM. de Verneuil and Collomb).



a. Silurian.
b. Red sandstone and variegated clay (Trias).
c. Muschelkalk.
d. Calcaire Grossier.

From an abundant supply of instances of blanks (the indications of an emerged surface) those described in this memoir have been selected, as apt to our purpose, and having an ascertained horizon. They are given in descending order, each successive epoch supplying the roof of a blank.

II. Instances of Blanks or Gaps.

1. *With a Quaternary Roof.*—Throughout by far the greater part of the extensive countries of Norway, Lapland, Sweden, and Finland, Quaternary Diluvium and Northern Drift lie directly on Laurentian and Huronian rocks; little or no deposition having taken place there (through 25° of longitude and 13° of latitude) during the vast interval of time between that of the contiguous formations. Marks of denudation are many and powerful here; and though there are patches of younger strata, they do not require notice from us.

On the opposite coast of North America all this is repeated, through Labrador and Canada to beyond the Upper Mississippi River, in a broad belt of rugged land 2000 miles long, where no Mesozoic nor old Tertiary rocks, loose or fixed, have been met with, though often looked for. From this block of older metamorphic formations another broad band of the same antiquity, sprinkled with sand, gravel, and boulders, runs from Lake Superior into the Arctic Ocean, through Rupert's Land, for 1500 miles*. Messrs. Foster and Whitney also remark that "Between the Northern Drift of the south side of Lake Superior and the Devonian there are no deposits, but

* Quart. Journ. Geol. Soc. vol. xi. p. 500.

an immense gap in the series of formations. Of the condition of the ancient surfaces we have no evidences; but we now see it covered with stratified drift of sand and clay, sometimes 1000 feet above the present level of the lake." *

In Nova Scotia there is, according to Dr. Dawson †, no formation between the Drift and the Upper Trias.

An important section, running 550 miles due east through the States of Mississippi, Alabama, and Georgia, from Vicksburg on the Mississippi to the Atlantic, has been pointed out by Sir Charles Lyell ‡. It gives successively Loess, Eocene, Chalk, Coal, and Granite, and again, on the other side of the range, Coal, Chalk, Eocene, and Loess; and thus tells of four blanks or gaps on opposite sides of the central mountains (granitic and metamorphic), each showing the absence of several assemblages of strata. In South America, the two Guianas, Brazil, and Chili present large surfaces of Palæozoic and other rocks covered by Quaternary beds §.

Large portions of the Ural Mountains, and especially their eastern flank, have no deposits between the Drift and the Carboniferous rocks; and the same may be said of Siberia, showing that it was for a long time a subaërial continent, although in parts not without newer sediments ‖.

The Quaternary beds on which the town of St. Girons (France) stands most probably conceal the Lias, as is certainly the case at Audinac, close by ¶.

At Maubert Fontaine, in the Ardennes, loose Quaternary beds repose on Silurian schists **; and Della Marmora †† reports several similar cases in Sardinia.

It is an old observation of the late Mr. Warburton, and quoted by Sir Henry De la Beche ‡‡, that the alluvial beds in which the bones of Elephants are found, in consequence of previous denudation, are discovered resting on the blue clay of London, Oxford Clay, or any other bed.

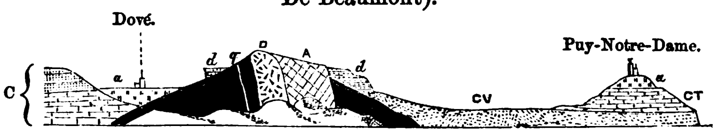
These few examples have their analogues abundantly in other countries, and they form no insignificant part of the earth's surface, especially when we take into consideration other gaps commencing with lower epochs.

2. *With a Tertiary Roof.*—Sir Roderick Murchison §§ found on the River Vaga, in northern Russia, a beautiful section of Pleistocene strata resting conformably on horizontal Permian beds. It therefore indicates the prolonged rest of that country. In like manner

* Geol. Surv. of Lake Superior Land Districts.
† Quart. Journ. Geol. Soc. vol. xii. p. 103.
‡ Second Visit to the United States, vol. ii. p. 279.
§ D'Orbigny, 'Voyage dans l'Amérique Méridionale,' vol. iii. 3e partie, pp. 210, 222, &c.
‖ Murchison, 'Geology of Russia,' vol. i. pp. 352–391.
¶ D'Archiac, 'Histoire des Progrès de la Géologie,' vol. vi. p. 550.
** Gosselet, Bull. Soc. Géol. de France, 2e série, vol. xviii. p. 5.
†† Voyage en Sardaigne, vol. i. p. 414.
‡‡ Mem. Geol. Survey of Great Britain, vol. i. p. 239.
§§ Geology of Russia, vol. i. p. 331.

Cap la Hêve *, near Havre, exhibits Upper Tertiary strata lying horizontally and conformably on abraded Lower Greensand. M. Elie de Beaumont gives an instructive example of Miocene beds at Clain †, covering an ancient gneiss; but a few hundred yards off also incumbent on Lias and other Lower Secondary rocks, the gaps therefore being numerous. Messrs. de Beaumont and Dufrénoy also give us in the section below a most interesting series of blanks or absences, as will be understood without explanation ‡. Dr. Von Dechen § describes the Miocene lignite-beds of the Siebengebirge as reposing on Upper Devonian rocks; and thus exhibiting an interval of fifteen of D'Orbigny's stages; in this case, probably, through denudation.

Fig. 3.—*Section from Dové to Puy-Notre-Dame* (after Dufrénoy and De Beaumont).



a. Miocene.
CT. Tufaceous Chalk.
C. Greensand.
CV. Lower Greensand.
d. Jurassic.
e. Micaceous and talcose schist.
A. Devonian.
D. Diorite.
q. Vein of black quartz.

M. d'Orbigny ‖ gives several instances of great blanks beneath the Miocene stage, as in the Department of La Manche, where the latter rests on Trias; there being in that district a void of twenty-five of his stages. In the Ligurian basin this author says that patches of the Faluns lie directly on Azoic or Plutonic rocks, with the loss of twenty-five stages. At Gahard they cover Palæozoic strata, twenty-two stages being absent; and at Tournay (Deux Sèvres), &c., they overlie Chalk, four stages being missing.

M. d'Archiac ¶ quotes M. Ribiero as stating that, four miles north of Thomar in Portugal, lacustrine limestones of the Miocene age are underlain by Upper Lias and Trias. At the foot of the Sierra Morena, near Cordova, and over extensive districts, Miocene is incumbent horizontally on inclined Carboniferous strata. It was first seen by the late Mr. S. Peace Pratt **. A remarkable series of gaps, indicated by the absence of Chalk, Oolite, Permian, Devonian, &c., is described by Prof. Peters †† as occurring near Bleiberg. The section begins with

* Dufrénoy and De Beaumont, 'Explication de la Carte Géol. de France,' vol. ii. p. 198.

† *Ibid.* vol. ii. pp. 124, 125.

‡ As all the Sections are self-explanatory, each will be found at the head of the period to which it refers, without any further notice.

§ Bull. Soc. Géol. de France, 2e série, vol. x. p. 319.

‖ Cours de Paléontologie, vol. ii. p. 768.

¶ Histoire des Progrès de la Géologie, vol. vii. p. 217.

** D'Archiac, 'Histoire des Progrès,' vol. iii. p. 9.

†† "Die Umgebung von Bleiberg," Jahrbuch der k. k. geol. Reichsanstalt, &c. vol. viii. p. 67.

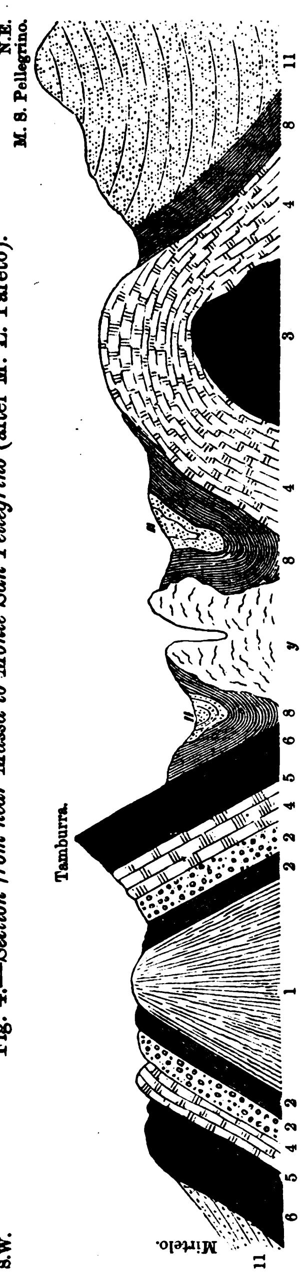


Fig. 4.—*Section from near Massa to Monte San Pellegrino* (after M. L. Pareto).

1. Gneiss and schists.
2. Upper Verrucano.
3. Black marble or Bardilio (Triassic).
4. Liassic marble and schist, with *Ammonites*, &c.
5. Jurassic Clay-slate.
6. Upper Jurassic black dolomitic limestone.
8. Galestro schists.
11. Macigno (Eocene).
y. Ophiolite.

Tertiary strata, which rest directly on Lower Lias; and then occur successively, in descending order, Upper and Lower Trias, Carboniferous schists (diorites intercalated), conglomerates, mica-slate, and, finally, gneiss. It is occasionally seen that the Tertiary beds* of the great plains of Prussia, which stretch uninterruptedly from the mountains of Saxony, Magdeburg, and Brunswick, northwards to the sea, repose on the Muschelkalk.

Sir R. I. Murchison † discovered that on the northern edge of the Bavarian and adjacent Alps, the upper part of the Eocene formation (together with some Miocene strata) was either never deposited or had been swept away; and he justly considers their absence an important fact. The Tertiaries of these countries have no connexion with the Chalk.

General Della Marmora ‡ met, near Pianedda and Gonessa, as well as on Mount Cardiga, in Sardinia, as also at Goni and Terra Segada, in the same island, with Nummulite-limestones and sandstones incumbent horizontally on the upturned edges of Silurian schists.

The Lower Eocene §, with Nummulites, forms the roof

* Histoire des Progrès de la Géologie, vol. viii. p. 522.

† Quart. Journ. Geol. Soc. vol. v. pp. 227, 228.

‡ Voyage en Sardaigne, vol. i. pp. 32, 228, 233. See also Lyell's 'Principles,' p. 187 (on the Pyrenees).

§ D'Orbigny, 'Cours de Paléont.' vol. ii. p. 701.

of a considerable gap in the same parts of Europe. In France it covers Neocomian at Orgon, there being six of D'Orbigny's stages missing. At Aude it is placed on Palæozoic rocks, and in the Department of the Var it is on Jurassic. In Brittany it overspreads successively Cretaceous, Jurassic, Palæozoic, and Azoic rocks. Mr. Hamilton (our present President), in one of his addresses *, deriving his information from Captain Grant and others, informs us that wide expanses in India, namely, in Scinde, Cutch, Beloochistan, and the Punjaub, are covered with Nummulitic Limestone capping arenaceous and clayey strata, which lie, not on Cretaceous, but on Jurassic or some still older bed.

On the Upper Missouri, Dr. Hayden †, in 1861, described Eocene strata lying first upon some thin Cretaceous and Jurassic beds, and then on Primordial sandstone, supported unconformably by Laurentian gneiss and granite. Here, therefore, the gaps are many and very great.

Nummulite Limestone rests, near Thun, on Neocomian ‡, and in the Diablerets on Gault, the fossils of the two formations being sometimes mingled together.

3. *With a Cretaceous Roof.*—Premising a few words on the members of this formation, I may observe that a valuable table, drawn up by Vicomte d'Archiac, and referring to seventy-one different regions, both small and large, enables me to state that, massing together all the subdivisions of the Cretaceous series, little more than one-third of the whole has been actually laid down in these seventy-one countries. They are found in twos and threes; and it is exceedingly rare to find the whole, or nearly the whole, succession in one place. Gaps, therefore, among the members of the chalk-beds, implying subaërial conditions, are all but universal in space and time; and this is the case also in other portions of the sedimentary series. We see from this elaborate table § that of our four Cretaceous groups, 1, White Chalk; 2, Chalk-marl and Upper Greensand; 3, Gault; 4, Neocomian, the most constant is the second, for it occurs in 65 regions out of 71; then comes the first, found in 38 regions; the fourth in 32; and the third only in 13 regions.

As to their thickness, and the lapse of time represented, they are in the following order:—the fourth group is the thickest; then the second, first, and third successively.

The series is most complete in England and France; next follow the north of Germany, and the province of Constantine in Algeria.

The south flank of the Maritime Alps and the north flank of some of the other of those high ranges present, each, six subdivisions of Cretaceous rocks (13 in the whole series, D'Archiac); but elsewhere over the surface of the globe, as far as is known, this formation may be described as poorly, or very poorly, represented, or quite absent; although in some parts, as in North America, its superficial extent is

* Quart. Journ. Geol. Soc. vol. x. p. 1.
† Annals of Nat. Hist., 3rd series, vol. xi. p. 371.
‡ D'Archiac, 'Histoire des Progrès,' vol. iii. pp. 87, 89.
§ 'Histoire des Progrès,' vol. v. p. 610 *bis*.

vast. Thus, following the Chalk-beds from west to east, from the eastern frontiers of Gallicia and Podolia to the south end of the Oural Mountains, we have 30° of longitude, and from north to south, from Simbirsk to Orenburg, nearly 7° of latitude. Throughout the whole of this space we have only the White Chalk, and it is never more than 300 feet thick; and in Russia it lies exclusively on Oxford Clay, Kimmeridge Clay, and Portland Stone—a fact of great interest. The highly fossiliferous chalk of Trichinopoly and South Arcot is subdivided by Mr. H. T. Blanford * into six groups; and some of these are often missing.

a. *Chalk.*—The following instances of blanks occurring from beneath the Chalk might be multiplied almost indefinitely. Very many more are implied in the blanks treated of under other epochs. In most cases the area is considerable, and reaches to many hundreds or thousands of square miles.

The Cretaceous rocks in England are always unconformable to the Oolitic †, with considerable denudation of the latter, as in Oxfordshire (Prof. Phillips). There is, therefore, a hiatus between them.

According to Mr. Darwin ‡, Upper Cretaceous rocks lie on Jurassic strata in the Chilian Andes, Neocomian beds being absent; and at Coquimbo and other places Cretaceous and Jurassic fossils are intermingled in the same beds, from which it is inferred that the passage has been gradual, and that there has been no gap. On Lake Tiberius § and about the Dead Sea, in Palestine, in the Duchy of Brunswick ‖, on the north flank of the Hartz, Chalk covers Lower Jurassic strata ¶; while in the plains of Poland, Gallicia, and Volhynia it lies horizontally on the newest Jurassic. In the Department of the Var ** this rock caps Jurassic strata, which latter are incumbent on Bunter Sandstone.

In Yorkshire this formation rests both upon Lias and upon the curved and inclined beds of New Red Sandstone †† (Trias). Casiano de Prado ‡‡ found it, in the province of Segovia, to lie, by overlap, successively on Trias, Silurian, Gneiss, and Granite, all deeply denuded.

M. Ivanitski §§ met with Chalk lying directly on Keuper at Bakhmoutha (Donetz, Russia); and nearly the same thing occurs at Jumilla, in Spain, as we learn from a fine section in the Salines of Rosa ‖‖.

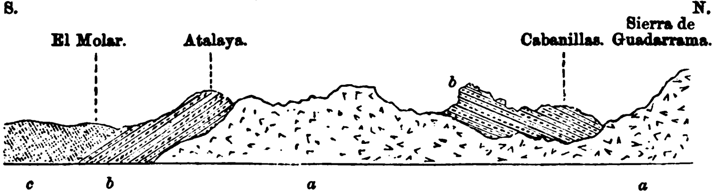
Chalk overlies Upper Carboniferous Limestone unconformably in

* Palæontologia Indica, vol. i. p. v.
† Jukes, 'Manual of Geology,' pp. 620, 621.
‡ Bull. Soc. Géol. de France, 2e série, vol. iv. p. 508.
§ D'Archiac, 'Histoire des Progrès,' vol. v. p. 388.
‖ *Ibid.* vol. vii. p. 511. ¶ *Ibid.* vol. v. p. 334.
** *Ibid.* vol. vi. p. 556. †† Lyell, 'Principles,' p. 187.
‡‡ Bull. Soc. Géol. de France, 2e série, vol. xi. p. 337.
§§ D'Archiac, 'Histoire des Progrès,' vol. viii. p. 567.
‖‖ De Verneuil and Collomb, Bull. Soc. Géol. de France, 2e série, vol. xiii. pp. 677, 683.

New Mexico * over large spaces; also in Texas and Tennessee, and over great tracts in the valley of the Missouri; thus indicating several extensive blanks.

The "Craie tuffeau," in Westphalia, covers Carboniferous schists and limestone †, and we have the same in the Don country of South Russia. At Harwich ‡, Kentish Town §, and Calais, deep borings, after having passed through the Cretaceous series, have struck at once into rocks apparently Palæozoic, and which at Calais are true Coal-measures. Near Seu d'Urgel, on the River Segra (N. Spain), M. Noblemaire || met with Cretaceous rocks resting on Upper Silurian; and M. Della Marmora ¶ describes them as reposing on Lower Silurian in Sardinia. Parts of Scania, in Sweden, exhibit the same kind of facts. At and about Segovia **, at Cerada and Lozoya (Spain), beds of this formation rest upon ancient schists and granite; we find them also upon the latter, extensively, in Saxony, in Sweden ††, in Southern India ‡‡, and (Hippurite limestone) at Tavolara, and elsewhere in South-west Sardinia §§.

Fig. 5.—*Section in the Sierra de Guadarrama, south of Cabanillas, showing Chalk resting on Granite of unknown age* (after MM. de Verneuil and Collomb).



a. Granite. *b.* Chalk. *c.* Diluvium.

In these twenty-eight instances of blanks, which were taken nearly as they came, the Cretaceous beds are found in contact with the following rocks (once sea-bottoms). They lie on Jurassic six times, Lias once, Trias four times, Carboniferous Limestone or schist seven times, on Silurian twice, and on old granite, gneiss, and mica-slate eight times.

Why the Chalk is not recorded as lying directly on Permian, Devonian, &c., I cannot tell; perhaps for want of a more extensive search.

b. *Upper Greensand.*—Neocomian, Gault, and Lower Greensand are missing in France, on the west side of the Anglo-Parisian

* James Hall, 'Boundary Report of Mexico,' vol. i. p. 117.
† D'Archiac, 'Histoire des Progrès,' vol. v. p. 224.
‡ Austen, Quart. Journ. Geol. Soc. vol. xii. p. 41.
§ Prestwich, *ibid.* vol. xii. p. 6, vol. xiv. p. 249.
|| Annales des Mines, 5e série, vol. xiv. p. 52.
¶ Voyage en Sardaigne, vol. i. p. 414.
** D'Archiac, 'Histoire des Progrès,' vol. v. p. 49.
†† *Ibid.* p. 251.
‡‡ Blanford, 'Palæontologia Indica,' vol. i. p. v.
§§ Della Marmora, 'Voyage en Sardaigne,' Part 3. vol. ii. p. 24.

basin, and in that of the Pyrenees; but the Upper Greensand occurs in both regions.

The transgressive and ever-varying relations of some deposits are finely illustrated by the Upper Greensand. It lies on Portland Stone near St. Jean d'Angilly; on Kimmeridge Clay at Cap la Hêve (Normandy) *; on Coral Rag at Ecommoy; on Oxford Clay at Dinas; on Kelloway Rock at Ballon, and on the Great Oolite. At Tournay this rock covers Coal-measures; at Tonvois, and in La Vendée, we find it on Azoic beds †.

Prof. Cook, from surveys and borings, has published ‡ some apparently accurate details on the true stratigraphical relations of the Greensand of New Jersey (North America); and he announces that it is in direct and discordant superposition to Laurentian gneiss.

Neither of these beds is seen on the north flank of the Pyrenees, nor on the Lower Pyrenees, in the Landes on the north-west, nor on the opposite border of the Cretaceous sea, in the Périgord, the Angoumais, the Saintonge, and finally in the basin of the Loire—and the result is a proportionately great gap. Dr. Geinitz does not admit the presence of Gault in the valley of the Elbe §.

c. *Gault and Neocomian.*—I have under this head only to mention that M. Lory || has recognized Neocomian strata resting on Oxfordian limestones in the Departments of the Drôme and the Isère, north-west of the town of Gap.

4. *With a Jurassic Roof.*—I shall be rather minute in treating of the omitted portions of the Jurassic strata, partly because we meet with good matter, and partly to show what the other periods would disclose if treated with equal fulness.

We shall find here denudation in general and intense activity, and suspension of the processes of deposit. We shall sometimes find much of the formation absent, and often notice its fragmentary occurrence, as well as its disguise by metamorphism; that process, however, from time to time relaxing in force, and then not destroying the characteristic fossils.

Rarely, if ever, is the Jurassic series complete. Generally we find only one of the four principal members ¶. The most constant, if we are to judge from organic remains, is the Oxford Clay; then the Lias; thirdly, the Lower Jurassic; and fourthly, the Upper Oolite, the smallest of them all, and not seen out of Western and Central Europe. A glance at Dumont's large geological map of Europe will show us very well the superficial extent of the European Jurassic formation. It appears to cross the English Channel from Dorsetshire into Western Normandy, and to proceed to near Angers (Department of Maine and Loire), and so on, in two principal masses, both directed E.N.E., into the Departments of Vienne, Cher, the

* D'Orbigny, 'Cours de Paléontologie,' vol. ii. p. 610.
† Lory, Bull. Soc. Géol. de France, 2e série, vol. xi. p. 782.
‡ Boundary Report, Mexico, vol. i. p. 128.
§ D'Archiac, 'Histoire des Progrès,' vol. v. pp. 46, 277.
|| Bull. Soc. Géol. 2e série, vol. xi. p. 782.
¶ D'Archiac, 'Histoire des Progrès,' vol. vii. p. 699.

Côte d'Or, the Doubs, and the Jura. From thence it proceeds E.N.E. by Schaffhausen and parts of Würtemberg, to near Ratisbon (Bavaria), and then is not visible eastwards until we reach Prussian Poland, where it shows itself in two basins, near Oppeln, and in Sandomir, respectively. North-east from this, the Jurassic series does not come into view until we arrive in the Russian Governments of Smolensko and Kalouga. From thence it spreads in broad sheets to near Moscow, where, with increased width, it occupies great spaces on the west side of the Oural, and as far north as the Icy Sea. It extends from near Moscow in a south-easterly direction to Astrakan, and to the Caspian, Aral, and Black Seas.

The Alps of Mid-Europe abound in Jurassic rocks, in several very interesting forms, which run down much of Italy in two long and narrow strips.

Of the Jurassic strata of America and of the remaining quarters of the globe no notice will be taken here, because they are too imperfectly known to answer our present purpose.

The facts now to be brought forward will place in a very strong light the flitting nature of the process of deposition, its rapid changes from the accumulation of vast masses to absolute cessation, causing the loss of important stages. We may consider, says D'Archiac *, that the chain of the Jura and its ramifications occupy the zone of the greatest normal development of this formation. Escher von der Linth also remarks that in the Western Jura of Switzerland, as far as Lucerne, no violent dislocation has taken place between the Jurassic period and that of the Chalk †. In the valley of the Saône hard by, about Mâcon and other parts, nearly the whole series of stages is frequently present ‡. But even here, among the mountain-ranges between the Rhone and the Rhine, the lower of the three Oolites is very feebly developed, and the beds are constantly varying by absence or by presence, in extent, thickness, and contents, everywhere. The occasional coarseness of the beds shows that they then must have been within the influence of wave-action. To go now to the Alps, Sir R. I. Murchison § concludes, as one result of his investigations, "that the Jurassic system of the Alps and Apennines is made up of two distinct calcareous formations, the inferior representing the Lias and Lower Oolites, the superior the Oxfordian group."

Here are important gaps; and we know that none of the sections, north and south of these mountains, are comparable with each other. Some member or other is absent from one, though present elsewhere. This irregularity and want of persistence in stages occasionally well characterized, and the sudden appearance and extreme thickness of some which are either altogether missing or very thin a few leagues off, are equally common and puzzling. Then, again,

* D'Archiac, 'Histoire des Progrès,' vol. vii. p. 600.

† Quart. Journ. Geol. Soc. vol. xi. part 2. p. 21.

‡ Berthand and Tombach, Bull. Soc. Géol. de France, 2e série, vol. x. p. 269; Thiollière, *ibid.*, 2e série, vol. v. p. 34.

§ Quart. Journ. Geol. Soc. vol. v. p. 307.

all these deposits being horizontal and undisturbed in one place, but fractured, faulted, displaced, and folded in another, makes the study of the Alpine Jurassic strata extremely difficult. This polymorphism of the Jurassic rocks of the north slope of the Alps we find represented in all the chains of *complex* mountains, that is, of those which owe their existence to a *repetition* on the same spot of the phenomena of fracture and upheaval.

On the south flank of the Maritime Alps*, and of Piedmont generally, there are, as far as we know, only two great Oolitic horizons, those of the Oxford Clay and the Lias, and these without any distinct subdivisions. Over large spaces, as on Monte Rosa †, Monte Cervino, the Gries Pass, in the Formazza Valley, and at Andermatt (Switzerland), the Jurassic strata, by metamorphism, become gneiss, and repose on another and older form of that rock. On the south slope of the Italian Alps ‡, as well as in Tuscany and in the Central Apennines, observers are agreed that the upper group of the Jurassic formation is wanting, and that the middle and lower groups are very poor, and represented rather by some species of fossils than by distinct beds; that the Lias is greatly developed to the exclusion of the rest of the series; and that the distribution of the fossils of these different stages does not constitute distinct faunas as in Western and Central Europe.

As to Italy, the Jurassic rocks, in the two districts in which they occur, have little thickness, and are defective in other respects.

In every direction from the Jura Mountains, and not southward only, this formation diminishes in completeness §, and becomes gradually simpler; for instance, as we advance eastward through Würtemberg, Moravia, and Silesia, until we arrive on the frontier of Europe and Asia, where it is found to consist of only a single term of the series. In these various countries the second group of Jurassic rocks is the sole representative of the epoch; and it is important to note that in Germany ||, in the broad interval between the Rhine and Vienna, the petrographical characters of the Jurassic beds, their local divisions, stratification, and fauna, all become incapable of detailed comparison with the type of the Jura chain, so great and multiplied have been the changes in the constitution of this formation from movements of oscillation of level.

In the South of France ¶, and in various other parts of that empire, the Oolite presents numerous irregularities in the deposition of its stages and groups; and there are many blanks, as in the Departments of Calais, the Var, and the Gard. The Upper Oolite is wanting on the east flank of the Beaujolais Mountains and on the south side of the Côte d'Or, while in the Valleys of the Isère, of the Drac, and in the Drôme the lower group is lost **.

* D'Archiac, 'Histoire des Progrès,' vol. vii. p. 281.
† *Ibid.* (Sismonda) vol. vii. p. 226. ‡ *Ibid.* vol. vii. p. 337.
§ D'Archiac, 'Histoire des Progrès,' vol. vii. p. 677. || *Ibid.* vol. vii. p. 703.
¶ Dufrénoy and De Beaumont, 'Explication Carte Géol. de France,' vol. ii. p. 555.
** D'Archiac, 'Histoire des Progrès,' vol. vi. p. 559, vol. viii. p. 193.

In Spain * all stages of the Oolitic series are poorly developed. The Oxfordian gives to it its chief feature, the others being quite rudimentary. In the Pyrenees the Oolite is distinctly seen, but it is in mere fragments (Leymerie).

The Oolite of England is more complete and better characterized than in most other countries; for in them it is everywhere imperfect, and in some places is thin, displaced, and even scarcely represented; but in England also, rich in mineral condition and fossil contents as the different beds often are, they are frequently either absent or non-persistent. All along the coast of Dorsetshire †, and indeed throughout the south of England, the Great Oolite is wanting; and commonly this series of beds is supported by Lias; but between Norton Phillips and Frome horizontal beds of the former abut against, not Lias nor Trias, but inclined strata of Carboniferous Limestone.

A formal description of the rocks of this epoch is not now our object; but we may add that, generally speaking, we find only one of the stages in the same locality: the most constant, as has already been observed, is the Oxford Clay ‡.

The peculiar circumstances attending the occurrence of the Oxford Clay, and especially its enormous range, must form my excuse for dwelling on it, before proceeding to point out some blanks connected with the Jurassic strata.

The Oxford Clay, with its beautiful fossils, which are said by D'Orbigny § to be identical from the equator to the pole, is spread over a far greater geographical space than any other stage of the Oolitic period. It occurs all through Western Europe, in England, Italy, Spain, France, and Germany ‖. Together with the Coral-rag, it gives to the Jura Mountains ¶ their strongest orographic characters. In the Salt Range of the Punjaub ** and in the Himalayas of Northern India it is very conspicuous; but in Russia it particularly claims the attention of the geologist.

Sir Roderick Murchison and his colleagues say that the Oxfordian is almost the only Jurassic bed in Russia ††. It is there capped by the Cretaceous strata, and lies on Palæozoic rocks, as near Plas, Mackariof, and Moscow; and whether seen near Moscow, on the Volga, in the Oural, or in the Petchora Valley, &c., its composition is surprisingly uniform. It is always very thin, and is accompanied by shreds of Kelloway Rock, Coral-rag, or Calcareous grit.

Sir Roderick was rightly much struck by the simplicity, uniformity, and thinness of the Russian Jurassic strata, which doubtless continue, on the north-east, across the immense plains on the coasts of the Icy Sea to New Siberia, and extend over 100° of longitude and 27° of latitude. The necessarily uniform action which must have prevailed over this vast surface is not without its

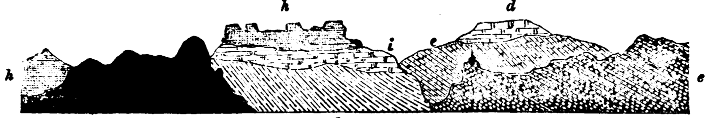
* D'Archiac, 'Histoire des Progrès,' vol. vi. pp. 163, 206.
† *Ibid.* vol. vi. p. 102. ‡ *Ibid.* vol. vii. p. 699.
§ D'Orbigny, 'Cours de Paléontologie,' vol. ii. p. 521.
‖ D'Archiac, 'Histoire des Progrès,' vol. vi. p. 100.
¶ *Ibid.* pp. 50, 56, 57. ** Quart. Journ. Geol. Soc. vol. ix. p. 194.
†† Geology of Russia, vol. i. pp. 230, 231, 245, 247, 253, 256, vol. ii. p. 428.

parallel, namely, the Estuarine beds of the Pampas of South America, the phosphatic deposit in Russia, and the deposit of chlorite-earth on the south side of Lake Superior; but the upper and lower lacunæ brought to light here have no equal in dimensions. The upper is bounded by White Chalk and the Oxford Clay, and the strata absent are portions of the Cretaceous series (including all the Neocomian) and much of the Jurassic. The lower gap is made by the loss of the Lower Oolite, the Lias, the Trias, and often the Permian; the Oxfordian always resting either on Permian or Carboniferous. The Chalk and the Oxford Clay (the latter being floor and roof at the same time) of this great region were therefore above water during the deposition elsewhere of the remaining Secondary rocks. These remarkable blanks are not so distinct and continuous in Western Europe; for there the Secondary formations are better represented. In the Doubs and the Cevennes (France) the Oxford Clay is followed normally by the lower rocks; and in other parts of France it is supported by the Great Oolite and other members of the third group *.

The following is only one instance out of many in which the great eastern blank is filled up in the west; but as it is very striking, it may receive brief notice. It is seen in a section of the Jurassic rocks extending from Donzenac † (Department Corrèze) to Sasseginnies (Lot), in the south-west of France. In the interval between these two towns seventeen important stages, between Tertiary strata and a gneiss, probably Laurentian, succeed each other conformably. These stages represent Chalk, beds belonging to each of the three Oolite Groups, four beds of Lias, Keuper and red clay of the Trias, two Carboniferous beds, a roofing-slate (Silurian?), mica-slate, and, lastly, gneiss.

a. *Oolite.*—I will now mention some of the blanks which begin at the Oolite, as a few out of the many; my difficulty throughout this paper being not to overload the subject.

Fig. 6.—*Section near Albarasin, between Madrid and Alicante, showing Oxford Clay resting on Lias, and Trias on Silurian* (after M. Collomb).



d. Oxford Clay.	*i.* Muschelkalk.
e. Lias.	*k.* Bunter Sandstone.
h. Clay and Gypsum (Trias).	*m.* Silurian.

M. Triger ‡ gives a large and beautiful section from near Mans, which tells us of the absence of the Great Oolite, and of a vast gap from the Lias-marls down to the schists of the Lower Silurian.

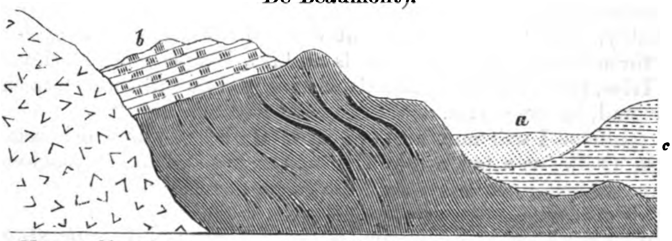
* D'Archiac, 'Histoire des Progrès,' vol. vi. p. 464.
† *Ibid.* vol. iv. pl. 2. fig. 1.
‡ Bull. Soc. Géol. de France, 2e série, vol. vii. p. 762.

M. Hébert * also points out in a striking manner the variable nature of the Jurassic rocks of France, from the frequent oscillations then affecting the north of that empire. In the Grindelwald † (Switzerland), and in large areas around, M. Escher von der Linth found Jurassic beds superposed directly on granite and subcrystalline rocks. In the Valley of St. Ortee Mannee, and at Perdas de Fogue (Isle of Sardinia), a magnesian limestone (Jurassic) covers horizontally carbonaceous shales, which, in their turn, rest on Lower Silurian, and thus indicate two separate and large blanks. We miss Lias, Trias, Permian, Devonian, &c. ‡; and I infer, among other things, that a Carboniferous basin laid long bare to the sky; but not without effect, as we shall see.

In the South of France, M. Fournet § met with Oxford Clay resting on Trias, near Valence, and likewise near St. Ambroux.

In Poland, Oolite is incumbent on Muschelkalk, and the sandstone of its third stage on both porphyry and melaphyr ‖; Oxfordian also rests on Muschelkalk in the Himalayas ¶. The Jurassic series is in two places on Carboniferous shales in Sardinia **, and once in Poland ††. In the latter country we find it on Carboniferous sandstones, as well as in France.

Fig. 7.—*Section at Rochebelle, near Alais* (after Dufrénoy and De Beaumont).



Metamorphic rocks. Coal-measures.

a. Alluvium. *b.* Jurassic limestone. *c.* Lower Chalk.

In Russia we have seen that the Oxfordian always rests either on Permian or Carboniferous (Murchison, *passim*), and in the Mendip Hills ‡‡ (Gloucestershire) on the latter. In the Napoleon Quarry §§ of the Bas Boulonnais this formation is met with on Lower Silurian, with, of course, the omission of many great epochs.

I have now shown how variable in quantity and constitution is

* Comptes Rendus, vol. xliii. p. 853.
† D'Archiac, 'Histoire des Progrès,' vol. vii. p. 553.
‡ Della Marmora, 'Voyage en Sardaigne,' vol. i. p. 111.
§ D'Archiac, 'Histoire des Progrès,' vol. viii. p. 193.
‖ *Ibid.* vol. vii. p. 553.
¶ Strachy, Quart. Journ. Geol. Soc. vol. vii. p. 306.
** Della Marmora, 'Sardaigne,' vol. i. p. 111.
†† D'Archiac, 'Histoire des Progrès,' vol. vii. p. 553.
‡‡ Ramsay, Mem. Geol. Surv. Great Britain, vol. i. p. 320.
§§ Dufrénoy and De Beaumont, 'Explication Carte Géol.' vol. ii. p. 155.

the Oolitic formation, and have selected fifteen cases of gaps in different countries, besides the two mentioned in Table B, passing in silence many more. The reader will perceive how frequently the subject has been enriched by the valuable writings of Vicomte d'Archiac.

b. *Lias.*—As in the Oolite just reviewed, so in its closely connected group, the Lias, all its parts are seldom found in the same place. Beyrich reports that the first stage is absent on the north side of the Hartz*. We seek in vain in the Swabian Lias for Corals, which are especial evidence of shallow seas; while Calvados is very rich in them. In Burgundy, the Jura Mountains, and Normandy, whole banks and reefs of Corals are met with in the Brown Jurassic rocks; in Swabia they are rare †.

In Würtemberg, where this formation is well developed, it is never complete ‡; and Chev. von Hauer, in the eastern or Austrian Alps, perceived that one or two terms were always missing §. In the Bocage of La Vendée, Fournet ‖ says there is no Lower Lias, and very little of Upper; and in the Swiss Jura the Lower Sandstone of this group is absent ¶.

In his Bridgewater Treatise (vol. i. p. 307), Dr. Buckland gives two excellent proofs of the occurrence of an interval between the deposition of the component parts of the Lias: the one is from the floor being sprinkled with coprolites; and the other the fact of the Belemnites lying in thousands, spread out horizontally, and covered with Serpulites and Mollusks. In two cases the Lias rests on Carboniferous Limestone (France and Wales)**. In two others it lies on Old Red Sandstone (Scotland and Wales ††), and in two more on Silurian in France (Gosselet and De Beaumont ‡‡). It lies on an old granite in the Valley of the Yonne (France §§), and on metamorphic rocks in Scotland ‖‖.

The nature of the gaps resulting from these imperfect stratigraphical sequences is easily recognized.

5. *With a Triassic Roof.*—There are extensive blanks, of which Triassic rocks form the roof. In the *central part* of Russia in Europe ¶¶ this formation does not exist. Of Muschelkalk there is not a vestige in England (unless we consider the waterstones as such), nor in the large tracts of Trias in France—in the Departments of the Saône and Loire, of the Côte d'Or and the Rhone, and the mountains of Charolois and Tararc ***.

* D'Archiac, 'Histoire des Progrès,' vol. vii. p. 518.
† Fraas, Quart. Journ. Geol. Soc. vol. vii. p. 43.
‡ *Ibid.* p. 459. § *Ibid.* p. 394.
‖ Bull. Soc. Géol. France, 2e série, vol. xvi. p. 416.
¶ D'Archiac, 'Histoire des Progrès,' vol. vii. p. 74.
** Fournet, Bull. Soc. Géol. France, 2e série, vol. xvi. p. 416; De la Beche, Mem. Geol. Survey, vol. i. pp. 262, 269, 279.
†† Portlock, Quart. Journ. Geol. Soc. vol. xiv. p. cxxxvii.
‡‡ De la Beche, Mem. Geol. Survey, vol. i. pp. 262, 269, 279.
§§ Ebray, Bull. Soc. Géol. France, 2e série, vol. xvi. p. 427.
‖‖ Portlock, Quart. Journ. Geol. Soc. vol. xiv. p. cxxxvii.
¶¶ D'Archiac, 'Histoire des Progrès,' vol. viii. p. 566.
*** De Beaumont and Dufrénoy, 'Explication Carte Géol.' vol. ii. p. 99.

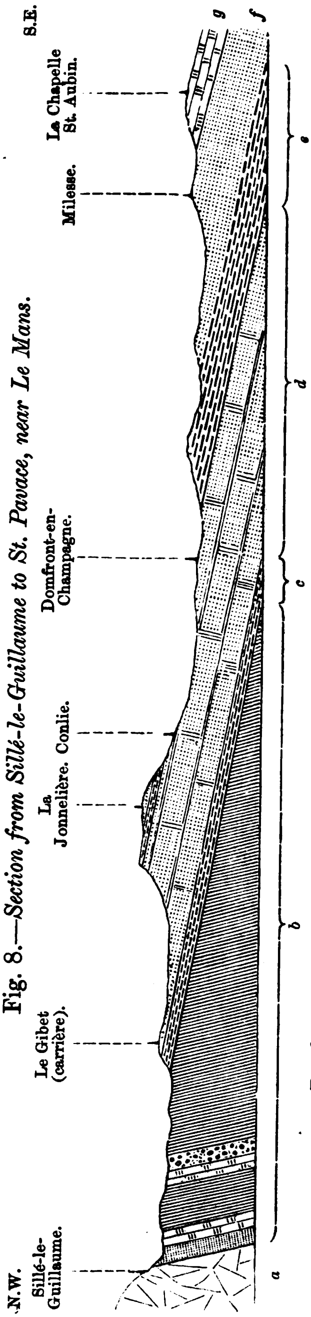


Fig. 8.—*Section from Sillé-le-Guillaume to St. Pavace, near Le Mans.*

a. Porphyry.
b. Lower Silurian.
c. Upper Lias.
d. Inferior Oolite.
e. Oxford Clay.
f. Greensand.
g. Fontainebleau Sands.

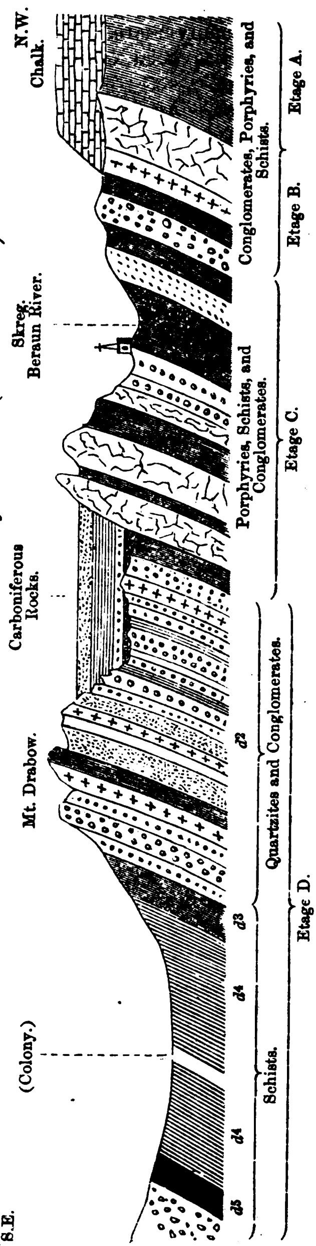
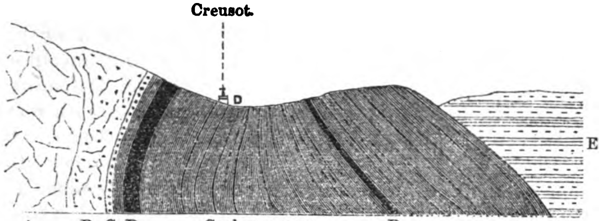


Fig. 11.—*Section of part of the Silurian Basin of Bohemia* (after Barrande).

Fig. 9.—*Section of the Coal-basin of the Saône et Loire* (after Dufrénoy and De Beaumont).

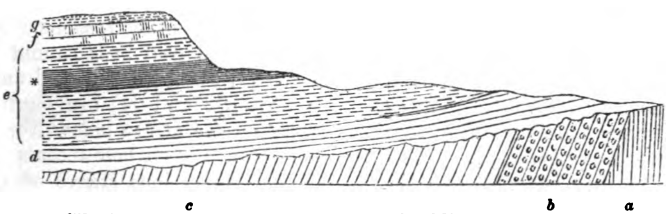


A. Granite.
B. Porphyry.
C. Pudding-stone.
D D D. Coal-beds.
E. Keuper.

At Sierck, on the Moselle*, all the three members of the Trias, considerably inclined, lie on old quartzose rocks, also inclined, but in another direction. The Triassic strata of South Staffordshire † are in contact with Silurian; both Carboniferous and Devonian being missing in parts. D'Orbigny mentions a similar instance in South America. The Upper Trias (4500 feet thick) of the eastern or Atlantic flank of the Appalachian Mountains abuts upon the older metamorphic rocks, and thus indicates the absence of five great formations ‡. The Triassic coal-field, near Richmond in Virginia, is superimposed on a granite newer than itself; for it is penetrated by veins of the latter.

6. *With a Permian Roof.*—A few examples must suffice in evidence that gaps are not uncommon between this formation and those below it. They occur in countries very distant from each other, and differ from those of other epochs in the interval rarely consisting even of one whole period. They are, as far as known to

Fig. 10.—*Diagram showing the general Relations of the Palæozoic Rocks of Saxony* (after Murchison and Morris).



a. Silurian.
b. Devonian.
c. Lower Carboniferous.
d. Upper Carboniferous.
e. Rothliegende. } Permian.
* Plant-beds.
f. Zechstein.
g. Sandschiefer.

* De Beaumont and Dufrénoy, Explication Carte Géol. vol. ii. p. 13.
† Jukes, 'Bibliothèque Universelle de Genève,' vol. xiii. p. 69, 1850.
‡ Emmons, 'Geology of North Carolina,' 1856.

me, simple discordances, but with interspaces of conglomerate (South America*, Russia†).

In England, and in many other places, the Permian usually graduates into the Carboniferous; but in the north of England Prof. Sedgwick has observed its lowest beds resting unconformably on the Coal. And the same holds good with the Dolomitic Conglomerate of the neighbourhood of Bristol, and also with respect to the south-eastern part of the South Wales coal-basin. In like manner De la Beche‡ has inferred great disturbances after the deposition of the Coal-measures, the effect being to place the various Permian beds unconformably in places on the Carboniferous rocks.

Sir R. I. Murchison § met with the same facts in Russia over great regions (Oural), though elsewhere, in that country, there is a distinct transition between the two formations in question.

The Permian of Kansas ||, in North America, is superposed conformably on Carboniferous shales, clays, and limestones, with intermixture of their organic remains; but that of Illinois (North America) is reported by Mr. Worthen ¶, the Government Geologist of that State, to lie unconformably on Carboniferous rocks in a highly disturbed country.

Mr. David Forbes **, in his paper on South American geology, found the Permian among the vast sedimentary accumulations of that part of the world; it lies in discordance as regards the Devonian at Coniri in Bolivia, where the red conglomerates, the lowest of the series, abut against the nearly vertical Devonian shales.

7. *With a Carboniferous Roof.*—It will probably be seen, in a later part of this paper, that unusually large expanses of emerged land existed in several parts of the world during the Carboniferous period.

As in the case of all the preceding strata, the different parts of the Carboniferous deposits vary greatly with the locality. This applies, according to Logan, Dawson, and Lesley ††, particularly to Nova Scotia. They are here very minute and almost endless. In Missouri, Prof. Swallow has divided the whole coal-field of that State into seventy-five parts, from mineralogical and other reasons. All these parts vary in thickness, and the several coal-beds cannot be identified except by their position with respect to the hydraulic limestone (No. 66). The coal-beds (Nos. 62 and 64) are wanting in many places; and in Marion County all the strata below No. 60 have disappeared ‡‡. The intervals of non-deposit below coals are of various extent; and they commence at various stages of the epoch. In England and in Western Europe, according to Murchi-

* E. Forbes, Quart. Journ. Geol. Soc. vol. ix. p. lxx.

† *Ibid.* vol. v. p. li.

‡ Travels in South America, vol. iii. p. 60.

§ Geol. of Russia, vol. i. p. 146.

|| Meek and Hayden, Proc. Acad. Nat. Sciences Philadelphia, 1859.

¶ Meeting of the American Association for the Advancement of Science, Baltimore, 1855?

** Quart. Journ. Geol. Soc. vol. xvii. p. 38.

†† Lesley, American Journal of Science, 2nd series, vol. xxxvi. p. 183.

‡‡ Swallow, 'Geol. Rep. of Missouri,' 1855, p. 86.

son *, the Coal-measures are generally in concordance with the Carboniferous Limestone; but this is not the case in parts of Bohemia and Poland, where great dislocations took place *after* the deposition of the Carboniferous Limestone, and *before* that of the Coal-measures. The former of those two, together with the Devonian and Silurian rocks, dips at a high angle, while the Coal-measures are horizontal. In this unconformity we have a breach and an interval of time represented. Sir R. I. Murchison observes that a great fracture between the lower and upper divisions of the Carboniferous groups extends not only throughout Germany, but through France also. Blanks whose roofs are of Carboniferous rocks are numerous, because coal-basins are numerous. Dr. Dale Owen † informs us that near the eastern limits of Montgomery County, Kentucky, a bed of coal rests on a Devonian sandstone (Chemung), the latter being on another sandstone full of the Cauda-galli fucoid. In Brittany ‡ and the west of France the Lower Carboniferous beds are in direct superposition to the Lower Devonian; and at Lesmahago § (west of Scotland) the coal-beds repose transgressively on several horizons—on the Old Red Sandstone, and Silurian of different ages. These three conditions arise from distinct crust-movements. At the mouth of the gorge of L'Echappe, in the valley of Firminy, it is interesting to observe that the Carboniferous sandstone, where in contact with the mica-slate, is composed of small and often angular fragments of the slate; thus indicating an interval of time between their deposition. Their respective dips are different ||.

Out of thirty-two instances, from my ordinary note-book, of blanks downwards from the Coal-formation, twenty have their base on Silurian strata, partly because they are stratigraphically near; but still a blank of great duration is involved. A few instances will now be stated, and some of the rest will be referred to in a foot-note.

Fig. 12.—*Section showing Coal-measures lying unconformably on Lower Silurian* (after Hall and Daniell).

a. Calciferous Sandstone.
b. St. Peter's Sandstone.
c. Trenton Limestone
d. Coal-measures.

Prof. James Hall, of Albany (in a short tract, published separately), describes Coal-measures lying unconformably on Trenton Limestone,

* D'Archiac, 'Histoire des Progrès,' vol. iii. p. 135.
† Geol. Surv. Kentucky, 4th Report, p. 341.
‡ Murchison, 'Siluria,' 3rd edit. p. 441.
§ Geikie, Quart. Journ. Geol. Soc. vol. xvi. p. 320.
|| De Beaumont and Dufrénoy, 'Explic. Carte Géol.' vol. i. p. 520.

in North Illinois. Both Dr. F. Roemer and Dr. B. F. Shumard* found on the River San Saba, in Texas, Carboniferous Limestone lying conformably on Lower Silurian (Bird's-eye Limestone), and the latter geologist saw it under the same circumstances in the Black Hills of the Upper Missouri. In the Upper Mississippi Valley† Coal-measures successively overlap the inclined edges of the subjacent rocks, from Carboniferous Limestone to Lower Silurian—a fact which has several points of interest. Mr. Lesley ‡ gives an instance at Arisaig, in Nova Scotia, of Coal-measures unconformable on the Clinton group (Upper Silurian). It is stated by Prof. Haughton § that on the west coast of King William's Island, in the Arctic seas of America, extensive beds of Carboniferous sandstone, with bituminous coal, capped by blue limestone of the same period (?), rest horizontally and conformably upon Upper Silurian.

Prof. Edward Forbes ‖ relates that, in the north of England, Carboniferous Limestone lies on highly inclined Silurian strata, the former being nearly horizontal. In South Staffordshire the Coal-measures usually lie directly upon Upper Silurian shale, &c., according to Mr. Jukes ¶ and others, in the midst of great denudation; and Mr. Godwin-Austen extends this statement to Wire and Charnwood Forests, as well as to Coalbrook Dale **.

On the River Jezem, in the Oural, Carboniferous Limestone reposes concordantly on Silurian masses ††.

In the foot-note ‡‡ are placed references to many cases of Carbonifero-Silurian blanks.

* Bull. Soc. Géol. France, 2ᵉ série, vol. xviii. p. 261.

† J. Hall, Amer. Journ. Science, 2nd series, vol. xxxiii. p. 294.

‡ *Ibid.* vol. xxxvii. p. 189.

§ M'Clintock's 'Voyage,' &c., Appendix.

‖ Quart. Journ. Geol. Soc. vol. ix. p. lxx.

¶ Mem. Geol. Surv. South Staffordshire Coal-field, 2nd edit. p. 180.

** Quart. Journ. Geol. Soc. vol. xii. p. 53.

†† Murchison, &c., 'Geol. of Russia,' vol. i. p. 409.

‡‡ The following are a few instances of Carboniferous rocks in contact with Silurian or other very ancient formations:—

Barrande, Bull. Soc. Géol. France, 2ᵉ série, vol. xi. p. 311, &c. Bohemia: on Azoic Rocks.

Murchison and Morris, Quart. Journ. Geol. Soc. vol. xi. pp. 417, 427. Thüringerwald and Saxony: on Gneiss.

Grüner, Bull. Soc. Géol. France, 2ᵉ série, vol. xvi. p. 414. Département de la Loire: on old Metamorphic rocks.

Murchison, Geol. of Russia, vol. i. p. 22. In the Donetz (11,000 square miles): on very ancient Crystalline rocks.

Ramsay, Lecture, Roy. Instit. Lond. 1858. On the Longmynd.

Nicol, Quart. Journ. Geol. Soc. vol. vi. p. 58. On Lower Silurian in South of Scotland.

Fournet, Bull. Soc. Géol. France, 2ᵉ série, vol. i. p. 785, and vol. vi. p. 626. Near Roannes.

Tract on Mississippi Carboniferous Limestone. James Hall. On Laurentian and on Trenton Limestone, North Illinois.

Tuomy, Report on Geology of Alabama, pp. 8, 11, 20, 26, &c. On Lower Silurian; very extensively.

Henwood, Trans. Roy. Soc. Cornwall, 1840. Nova Scotia: on Granite.

Shumard, Geol. Surv. Missouri, 1855. On Trenton Limestone, at Sulphur Spring and Salt Creek, Upper Mississippi.

H. D. Rogers, see Dana's 'Manual,' p. 228. Upper Silurian of Kittatinny Mountain lies unconformably on Lower Silurian.

8. *With a Devonian Roof.*—Prof. James Hall remarks * that the Chemung group of North America affords distinct evidence of its having been subaërial from time to time: in its ripple-marks, its ever-changing laminations, in the increasing quantity of its Plants, some being terrestrial and others marine, all of which facts bespeak the immediate proximity of land. There are in the Ithaca subdivision long but somewhat indistinct traces of lanceolate and falciform Plants; some are waifs, and others are natives. It is at Cooper's Town, on the eastern edge of the Hamilton Sea, where the earliest remains of terrestrial Plants have been found.

The Oriskany Sandstone (a Lower Devonian bed), thick in New York and Pennsylvania, almost entirely disappears, together with other members of this system, about the Upper Mississippi.

On the river just named, the Portage and Chemung groups, at the top of the Mid-Devonian, lie directly on the Hamilton Shales, and so create a gap. Here also we might expect the Cattskill Mountain group (Old Red Sandstone, or Formations IX. X. XI. of the Pennsylvanian Survey); but its place is occupied by great masses of Lower Carboniferous limestones, full of typical fossils, and covering Chemung rocks, a deep-sea condition having suddenly supervened.

In St. Louis County (Missouri), Chemung rocks repose directly on Trenton Limestone †, the great deposits between them having no representative there. In the Report quoted below, Dr. Shumard ‡ mentions a similar fact as occurring on Grassy River, in Rall's and Pike Counties, Missouri.

At Marston's Bridge, on the River Lamine (Missouri), the Devonian formation rests on Calciferous Sandstone (Primordial). Prof. Swallow gives a useful table, in which we see that many and extensive blanks occur in these highly interesting countries. In the centre of the State of Tennessee §, according to Mr. J. M. Safford, there is an area, about eighty miles in diameter, which was probably raised above the ocean by the disturbances at the end of the Lower Silurian period. Here an Upper Devonian Shale overlies Lower Silurian; both Upper Silurian and Lower Devonian being absent.

These same blanks or gaps are plentiful in Europe. The following are a few examples. As in America, so in Russia ‖ (at Czarskoe-celo) sandy and marly Devonian beds are conformably placed over Lower Silurian (Pleta Limestone), the Devonian rocks being loaded with Ichthyolites, and the Silurian with *Orthoceratites*, &c. In the middle of the Cantabrian Mountains ¶ (Province of Leon, Spain) and on their south flank are two bands of red limestone containing fossils indisputably Primordial. These two bands are at least seventy-five miles long **, and are vertical. They are enclosed conformably within massive beds of Devonian Sandstone. In this in-

* Palæontology of New York, vol. iii.

† Shumard, 'Geol. Surv. Missouri,' p. 184.

‡ Geol. Surv. Missouri, p. 123. § Dana's 'Manual,' p. 228.

‖ Murchison, &c., 'Geol. of Russia,' vol. i. p. 31.

¶ Casiano de Prado, Bull. Soc. Géol. France, 2e série, vol. xvii. p. 517.

** Casiano de Prado and Barrande, Bull. Soc. Géol. France, 2e série, vol. xvi. *passim*, and vol. xvii. p. 789.

stance the interval was great, and involved the occurrence of many lithological changes, and the appearance of many successive generations of living creatures, about the site of the blank.

M. Bureau *, in the course of some interesting observations on the geology of the Upper Loire, reports the conformable junction there of Devonian with Azoic rocks, and with the granite of La Vendée, both seemingly pre-Silurian.

The little we know of the Devonian formation of Ireland appears to promise the discovery of curious phenomena. Mr. Godwin-Austen considers much of it to be a fluvio-lacustrine deposit, and that it was a terrestrial surface anterior to the oldest sediment of the Carboniferous period. It lies, we must not forget to say, on Lower Silurian, and therefore marks the existence of a wide gap.

Mr. Tate found, in the Lammermuir Hills of the south of Scotland, Carboniferous rocks overlying Old Red Sandstone conformably; and then follows downwards a great blank, the Devonian being in unconformable contact with the so-called Cambrian rocks †.

The space allotted to this subject will allow me merely to mention that seventy-eight highly suggestive cases have been brought forward by Mr. John Kelly ‡, in which the Old Red Sandstone of Ireland rests upon beds belonging to thirteen different epochs; and forty-eight times on clay-slate and mica-slate.

9. *With a Silurian Roof.*—No inhabitants of dry land have as yet been found in the sediments of this epoch, except some spores and fragments of low-classed Land-plants. Prof. Edward Forbes's dredgings, however, have shown that this fact may lead to fallacious conclusions; and our Government surveyors § not very long ago determined that land did exist in Shropshire at this time; and they have begun to trace the boundaries of a Silurian sea-shore.

Potsdam Sandstone (Primordial) must have been frequently above the reach of wave-action, as we learn from the tracks of large Crustaceans, which may almost be said to be common near Perth, in Upper Canada, and a few miles west of Montreal.

The multitudes of large Coprolites found about the base of the Silurian strata for several thousand square miles of the lower part of the Valley of the Ottawa lead to a like belief. The districts join, and are nearly the same.

The Silurian formation, in all respects so instructive, behaves like those already reviewed. The remark of Prof. John Phillips ||, that no district yet discovered exhibits the Silurian deposits in their full development, is perfectly true. Abounding in blanks, its lost parts are innumerable, as Sir R. I. Murchison ¶ has shown in profuse detail.

A few distinct and authentic cases will now be produced, and references to others will be found in a foot-note.

* Bull. Soc. Géol. France, 2e série, vol. xvii. p. 789.

† Geologist, vol. iii. p. 240. ‡ Journ. Geol. Soc. Dublin, vol. vii. p. 122.

§ Lyell, Quart. Journ. Geol. Soc. vol. vii. p. liii.

|| Mem. Geol. Surv. Great Britain, vol. ii. p. 217.

¶ Siluria, 2nd edit. p. 111; and Murchison and Morris, Quart. Journ. Géol. Soc. vol. xi. p. 440.

Prof. Ramsay* finds Wenlock shale resting at right angles on upturned Llandeilo beds, and on the so-called Cambrian in the Shelve and Longmynd countries, as well as near Builth in Radnorshire; the gaps, in the Professor's opinion, being connected with denudation.

Chev. Fr. von Hauer †, assisted by eminent geologists, has executed a section across the Eastern Alps, from Passau to the Illyrian Karst. He found considerable Silurian beds on their north slopes, while on their south flanks these rocks are unknown, the older Carboniferous occurring in their place.

In British America, according to Sir W. E. Logan, the Lower Silurian occurs as tilted strata beneath the beds of the Upper, showing that an upheaval had occurred before the latter had been laid down. Similar facts have been observed at the eastern base of the Green Mountains of Vermont (U. S.), where limestones of Upper Silurian and Devonian age rest unconformably on the altered strata of the Quebec group ‡.

Dr. D. D. Owen observed §, on the south shore of Lake Winnipeg (Hudson's Bay), limestones of the Lower and, perhaps, of the Upper Silurian series lying on granite and syenite, without the usually intervening Primordial zone; as we likewise abundantly see at the village of Lorette, and on the sides of Cap Tourment, both near Quebec (Canada).

Wenlock ‖ is said to be the oldest limestone in the Arctic regions. If this be so, we have there either the non-deposit or the removal of the whole body of the Lower Silurian series.

In Iowa, on the west of the Mississippi, the upper beds of the Onondaga salt-group (Upper Silurian) are water-worn, and sometimes strewn with coarse sand and gravel, hardened occasionally into little patches of conglomerate; thus indicating, says Prof. James Hall ¶, a lapse of time before the deposit of the next succeeding stratum, some representative of the Lower Helderberg beds. The same eminent geologist remarks that ten of the seventeen Silurian stages found in the State of New York are wanting on the north of the River Ohio, or west of Lake Michigan—a very noteworthy fact **.

Since the happiest generalizations must rest on details, I am sure the Society will pardon the length of these.

* Quart. Journ. Geol. Soc. vol. ix. p. 175. † L'Institut, 1857, p. 30.

‡ Dana's 'Manual,' p. 226. § Geol. Report, Wisconsin, p. 182.

‖ Murchison, Quart. Journ. Geol. Soc. vol. xi. p. 537.

¶ Palæontology of New York, vol. iii. pp. 290, &c.

** With reference to a few other instances of intervals with a Silurian roof, consult the following authorities:—

Della Marmora, Geol. of Sardinia, vol. i. p. 29; on Granite.

Sharpe, Quart. Journ. Geol. Soc. vol. ix. p. 143; conformably on Coal-measures, at Brazielo and Quinta da Lomba, Portugal.

Tuomy, Geol. Rep. Alabama, p. 8; on old Metamorphic rocks, extensively.

Hall, Palæontology of New York, vol. ii. (introductory review) pp. 20, 22, 46; absence of various important parts of the Silurian system. Vol. iii. p. 36; Lower Helderberg rocks on Utica Slate.

Murchison. See 'Siluria,' 2nd edit. p. 111; Pentamerus-sandstone, at May Hill, on unfossiliferous slate (below Lingula-flags).

III. Conclusion.

1. *General considerations.*—Missing formations are among the several consequences of emergence and immersion, themselves the effects of one of the great cosmic agencies—oscillation of level—which may be gradual or paroxysmal, through all the degrees of velocity and energy.

Oscillation is, in a sense, universal in time and place; but, apparently, its action is irregular. While its influence is felt in most places, as well in the interior of continents as in the ocean depths, it is most easily detected near great waters; and there seem to be both great and small breadths of country which are at least places of *comparative* rest. The most conspicuous of these are the axial lines of Scandinavia and the South Seas; but Egypt *, parts of the Danubian Valley, of Borneo, and Venice (E. de Beaumont) all seem to have been long stationary. Oscillation is the result of a power which operates from beneath through all existing groups of strata. It necessitates and facilitates the emigration of animals and plants, kills or multiplies life, driving it far and wide in search of proper pressure, food, shelter, and such like. Great elevation conduces to variety in life, and great depression extinguishes the higher forms of life.

Emergence gives us dry land of different forms and heights, with processes belonging to the latter in action. Such tracts are surrounded by seas, which lay down their insoluble contents, and are charged with living communities during countless ages, largely fed and varied by the drainage of the emerged soil. The dry surfaces are subjected to a particular course of operations; minute subdivision, redistribution, and removal of their substance set in; and they undergo fertilizing and other changes from solvent, solar, and chemical influences. Marshes, lakes and rivers, ridges, slopes and plains, are formed, receiving stray germs of life from other quarters, which they nourish and multiply, but often suffer to perish. The dry land thus serves as a nursery and storehouse to the seas around it, as they lay down the representatives of a new epoch.

I will not follow this process now through its many changes, but must be well content to refer my readers to Dana's 'Manual.'

So much for emergence in few words; but denudation has also been a mighty agent in the destruction of strata and their contents. It must always occur at the point just before emergence is attained; and also when changes of level occur elsewhere within

* Prof. J. Phillips finds that the valleys of the Somme, of the Aire, and of Amiens have undergone no convulsion nor upheaval since the period of the *Hippopotamus major* and the Irish Elk. There has been simply a continuous river-action (Quart. Journ. Geol. Soc. vol. xvi. p. 54).

For points of rest, see Agassiz, in Bache's Report of the Atlantic Coast Survey, 1850; Hochstetter, New Zealand, Bull. Soc. Géol. de France, 2e série, vol. xvii. p. 108; Darwin, Edin. New Phil. Journ. vol. lv. p. 250; Phipson, Nieuport, West Flanders; Hugh Miller, Testimony of the Rocks, p. 124, Roman Wall, St. Michael's Mount; Rozet, Fixed Axis, Bull. Soc. Géol. de France, vol. xiii. p. 175; Durocher, Bull. Soc. Géol. de France, 2e série, vol. vi. p. 200.

certain distances; and therefore denudation must have been both common and extensive. Its enormous and wide-spread effects have hitherto not been sufficiently noticed. Masses of rock, many thousands of feet thick, have been pared, sliced off, and then swept away from the deposits of every great period; so that the earth's surface on which we now tread is not that which was inhabited by the extinct animals of bygone ages. It has been raised and depressed many times even since the Liassic period *.

As Sir Charles Lyell says †, "The evidences of the work of denudation are defective, because it is the nature of every destroying cause to obliterate the signs of its own agency." But this remark best applies to extreme cases.

The most material of these indications may be thus summed up:—The disappearance of a stratum may be attributed to denudation when its place is occupied by patches of the lost stratum, or by its boulders, grits, or sands, especially when its peculiar organic remains remain attached; when the basement-bed, burrowed by lithophagous mollusks, is polished, streaked, and guttered, or scooped into hollows, often very deep; when the lines of division are strong, all vestiges of transition destroyed, together with every mark of intermixture of fossil life.

M. Hébert, in his able paper on the "Oscillations of the North of France during the Jurassic Period" (Comptes Rendus, vol. xliii.), states that he has observed on the surface of certain strata, and especially on that of the calcareous beds, marks of polish, rubbing and excavation by water, together with lithophagous perforations in the same places, and often collections of rolled stones scattered about—the clear indications of emergence. They are to be seen, says Hébert, at several levels; and he cites in particular the quarries of Meziers and the Butte Chaumitton (Sarthe). Among other like facts, D'Orbigny gives numerous instances of the occurrence of sand, gravel, boulders, and transported mollusks between contiguous formations, as between Miocene and Lias, or between Neocomian and Chalk, or Upper Greensand, or Chalk-marl ‡.

The thinner the lost stratum, the sooner it is gone. Examples of these statements have been placed in the foot-note below §. In North America two very instructive instances on a large scale occur, in which

* Sir Henry De la Beche is our great authority on this subject, in the admirable thirty-seventh chapter of his 'Geological Observer;' and he has been more recently followed, with practical observations of great importance, by Prof. Ramsay, in the first volume of the 'Memoirs of the Geological Survey of Great Britain,' and in his Presidential Address of the year 1863 to this Society.

† 'Principles,' p. 154.

‡ Cours de Paléontologie, pp. 455, 640, 771, 783, &c.

§ The outliers and patches at Pradalis and Honrubio in Spain: Casiano de Prado, Bull. Soc. Géol. France, 2e série, vol. xi. p. 331. At Farringdon: Sharpe, Quart. Journ. Geol. Soc. vol. x. p. 182, &c. Scooping, &c., in South Staffordshire: Jukes, South Staff. Coal-field, p. 27. In the Onondago Salt-group and Delthyris Shaly Limestone: Hall and De Verneuil, Bull. Soc. Géol. France, 2e série, vol. iv. p. 657. The change from Bird's-eye to Trenton Limestone (Lower Silurian) at Fort Plain, &c., in the Mohawk Valley, is perfectly abrupt, and the fossils distinct, the two strata being in contact.

the effects of elevation, denudation, and deposition come successively into view. One is on the Upper Mississippi, and the other on the River Ohio; and they both, though not near each other, are on the same horizon. They consist of prolonged dome-shaped elevations of ruptured Devonian rocks, disclosing great masses of Lower Silurian, all now covered by Quaternary beds. Denudation by exposure to the weather, that is, to air and water, must be very slow; for Della Marmora gives a good woodcut of Cap de l'Ours, in Sardinia, which is so named from having from time immemorial resembled a bear. It is mentioned by Ptolemy, and therefore is still older than his time.

Mr. Darwin long ago showed that the great requisites for any large accumulation of sediment are three:—namely, (1) a long-continued supply of sediment; (2) an extensive and shallow sea; and (3) an area slowly subsiding to a great depth. How seldom, says he, in the present day do these conditions concur! Hence the general want of that close sequence in fossiliferous formations we might have theoretically anticipated.

A gap or blank is sometimes merely an omission—a defect in stratigraphical succession—and does not include any idea of vertical space. The expression refers to time as well as to deposits. Gaps are met with from the beginning of geological time, as far as that is known; and they show themselves throughout all epochs and parts of epochs, from place to place. (See the instances we have given.)

It may be remarked, and with surprise, that few examples are known where the absence of a set of strata is attended by, or in any way connected with, rupture of beds from beneath, or the outburst of igneous rocks; the occurrence has been usually due to broad elevation alone. Sections (Muirkirk Coal-field and Lesmahago), however, in Western Scotland, by Mr. Geikie *, may afford instances of this.

Some of the blanks are of limited extent, as when caused by the absence of a bed or two; but they are usually large, and in certain cases occupy an important portion of the earth's surface—one or more millions of square miles. Such are the Quaternary deposits resting directly on Laurentian, &c. (North America, South America, Scandinavia, &c.).

These gaps or blanks are often very large and numerous (existing contemporaneously and long); they arise from so many common and so many different floors or beginnings, that we may safely assume that, at various times and in a thousand ways, they ran together and coalesced into vast spaces of dry land of diversified geological structure, in the form of continents, peninsulas, and islands, just as we have it in the present day, and probably as extensively.

2. *Summary.*—The greater number of gaps, and especially of those which become important by reason of duration or size, spring from the Silurian, Carboniferous, or Jurassic ages; and this partly from

* Quart. Journ. Geol. Soc. vol. xvi. p. 322, pl. 18. fig. 3; (Murchison), *ibid.* vol. xii. p. 18.

their early date; an opportunity being thus afforded for possible or, rather, probable coalescence with other emerged lands. In the one hundred and fifty instances of gaps given in this paper (taken indifferently), forty-six times has the Silurian, in different parts of the world, formed the floors of gaps, which have extended up to nine different epochs; namely, into higher portions of its own period three times, into Devonian nine, Carboniferous thirty-one, into Trias and Lias once each, into Jurassic once, Cretaceous four, Eocene twice, and up to Quaternary four times. On three occasions the Silurian rocks have become the roof or covering to lower Palæozoic formations. The Silurian, we see, has to do with more than one-third of all the instances I have given, and must have had a wide diffusion.

The older Palæozoic rocks (including only Laurentian and some other metamorphic beds, once thought azoic) furnish us with the next greatest number of floors—twenty-five, or nearly one quarter of the instances. Here the epochs reached vertically by these twenty-five gaps, without intercalation or interference, are ten: namely, Silurian, Devonian, Trias, Lias, Jurassic, Neocomian, Chalk, Eocene, Miocene, and Quaternary. Most of these blanks, I need hardly say, are of incalculable duration.

The blanks commencing with the Carboniferous formation are twenty-two, or about one-seventh of our one hundred and fifty cases. They range upwards into seven separate epochs in separate countries—to the Permian and Jurassic six times each, to Upper Greensand, to Lias, and to Quaternary once each, and to Chalk five times, always indicating omissions greater or less in number. In addition to its importance as being the roof of the great Russian Carbonifero-jurassic gap, the Jurassic is the base or floor of ten other and newer sedimentary absences. Five occur in the midst of its own parts or stages, two extend to the Chalk, and three to the Tertiaries.

These four periods, the Laurentian, &c., Silurian, Carboniferous, and Jurassic, comprise one hundred and thirteen—more than three-fourths of our instances. Since these one hundred and fifty are mere representatives of great numbers of like phenomena, known, indeed, but necessarily unnoticed, we may infer that they are periods predominating and spread largely over the earth; and so field-observers tell us.

The Devonian occurs as a base but four times; that is, eight to a gap connected with Coal-measures, thrice with Lias, and once with Miocene.

Other epochs still more rarely form floor or roof. The Upper Mesozoic and Upper Palæozoic seem to be oftenest in connexion with gaps.

These gaps recur again and again, in the vertical column of sediments, upon the same locality or base, in consequence of what Thurman has formulated as the "*recurrence of elevation*" (repeated disturbance, in simple words), a fact well exemplified by M. Favre in a section of Mont Salève, near Geneva. The one hundred and fifty cases I have described introduce us to two separate gaps on the same spot ten times in the sedimentary column, to two threes

and two fours vertically. More than these could easily be collected, were it desirable. M. Ebray furnishes us, from Vespillière (Département Isère), with a vertical section, passing downwards from diluvium to Gneiss, through Jurassic, Liassic, and Carboniferous strata, where, on successive floors, at least ten great epochs are wanting *.

M. Thurman † gives a curious but not a unique section, which was brought to light in digging a well near Wietlisbach, 1100 feet deep. There are here not only several important strata missing (Lias, &c.), but the whole mass has been inverted. It is an overthrow: on the top are Keuper Marls and Muschelkalk, followed downwards by the Great Oolite and, finally, by Oxford Clay, largely developed.

3. *Inferences.*—The Laurentian, Silurian, Jurassic, and other gaps (naming them from their floors) occur on the same horizon in various parts of the earth; and, those of each series being approximately synchronous, though wide apart in solar time perhaps, they must frequently unite with neighbouring gaps (floors) of all ages, as they emerge to about the same level. The site of each is always passing through its own local changes, both in level and in various natural processes.

The duration of one of these blanks, as we have seen, varies beyond human estimate. We cannot comprehend the vastness of geological time. Where a blank only affects a few beds in the midst of an epoch, the time may be small; and this occurs perpetually: but they are usually long, and longest, according to our present knowledge, when we can count upwards from Laurentian to Quaternary; though the time must be very great when it endures from the Silurian to the Tertiary, of which interval we have four examples. In sixteen cases the Silurian waited open to the sky for the advent of the Carboniferous period, and was the base of forty-five gaps in all, as just stated.

The duration of these periods of suspension or denudation is best measured, though only relatively and remotely, by the number of lost epochs, or parts of epochs, which ought to have been between the floor and roof; thus Carboniferous upon Silurian involves far less unrepresented time than Eocene upon Silurian.

When the floor and roof of proximate epochs are conformable, or nearly so, and when their uniting surfaces show few signs of surf-action, the duration of the gap may be small; but it may be considered long when beds normally more distant from each other meet, when there is some discordance of position, and when there is an interspace, with fossils ground to powder, or occupied by foreign matters.

D'Orbigny (Cours de Paléontologie, vol. i. part 2. p. 500) gives a beautiful example of this in the littoral deposits of the Bathonian and Callovian stages of the Jurassic. He remarks, "We have seen that at Colleville and its vicinity the first-mentioned beds of the cliffs of that coast have been ground, corroded, polished by the waters, before the first clay-beds of the Callovian were laid down. To look at that

* Bull. Soc. Géol. de France, 2e série, vol. xx. p. 297.

† Fourth Letter on the Jura.

surface polished before these first deposits were made, and as it were gnawed, we acquire a certainty that that rock was already consolidated before the first life of the epoch following was buried there; and this implies a considerable lapse of time between."

Gaps are the most numerous in mountainous countries; they are, however, by no means the largest there, either vertically or horizontally. They appear to have the greatest horizontal extension in plains; and, further, it is probably true that the vertical succession of deposits is the most perfect in the least disturbed districts; which we see (with exceptions) in the gently undulating regions of New York State, and on the west side of the Mississippi.

It is true that the floors and roofs of gaps have no relation to each other but such as is impressed on them by crust-oscillation. There is complete stratigraphical independence of the two contiguous beds; the floor of the one is a *mere support* to the other, with no resemblance to the new deposit either in mineralogy or in fossil contents. The floor of the breach remained subatmospheric, and subject only to agencies already noticed, until immersion and its consequences covered it up.

Table A will be found useful by showing the epochal relations of roof and floor at a glance. Their total absence of anything like connexion in nearly all cases becomes in it at once manifest.

TABLE A.—*Synoptical View of the Roofs and Floors of Gaps in their Epochal Relations.*

Roofs of Blanks.	Floors of Blanks.																
	Pleistocene.	Pliocene.	Miocene.	Eocene.	Chalk.	Neocomian.	Jurassic.	Lias.	Trias.	Permian.	Carboniferous.	Devonian.	Silurian.	Palæozoic*.	Laurentian.	Plutonic.	Total Roofs.
Quaternary ...	1	1	1	1	...	...	...	...	1	1	1	...	4	1	4	...	16
Pliocene	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1
Miocene	...	...	...	1	1	...	...	1	1	1	...	1	...	1	...	1	8
Eocene.........	...	...	...	...	2	1	3	1	1	1	...	...	2	2	...	...	13
Chalk	...	...	...	...	...	1	2	1	3	1	5	...	4	8	...	...	25
Neocomian ...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1	...	2
Jurassic	...	...	...	...	...	...	5	1	1	1	6	...	1	1	...	1	17
Lias	...	...	...	...	...	...	...	...	...	...	1	3	1	1	1	...	7
Trias	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...	2
Permian	...	...	...	...	...	...	...	...	...	...	6	...	...	...	...	...	6
Carboniferous	...	...	...	...	...	...	...	...	...	...	2	4	31	...	...	...	37
Devonian......	...	...	...	...	...	...	...	...	...	...	...	...	9	...	1	...	10
Silurian	...	...	...	...	...	...	...	...	...	...	...	...	3	...	3	...	6
No. of Floors	1	1	1	2	4	2	10	4	7	5	22	8	56	14	11	2	150

* Rocks of doubtful age; but below Trias.

There are, however, other appearances which are worthy of notice. Those which refer to the mineral condition of the surfaces, and to

Table B.—*Showing the Stratigraphical Relations of the Floors and Roofs of Missing Formations* (Gaps).

Roof.	Floor.	Locality.	Author.	Reference.	Roof and Floor Conformably Inclined.	Roof and Floor Horizontal.	Roof and Floor Unconformably Inclined.	Floor Inclined.	Roof Horizontal.
Drift	Trias	Nova Scotia	Dawson	Quart. Journ. Geol. Soc., vol. xii. p. 102.	...	...	...	*	*
Drift	Eocene	Alabama	Lyell	American Journal of Science, 2nd series, vol. iv. p. 190.	...	*	...	...	...
Drift	Permian	Oural, R. Vaga	Murchison	Geol. of Russia, vol. i. p. 331.	...	*	...	...	...
Pliocene	Greensand	Cap la Hêve, France	De Beaumont and Dufrénoy.	Explication Carte Géol. de la France, vol. ii. p. 198.	...	*	...	...	...
Miocene limestone	Coal-measures	Cordova, Spain	De Verneuil	D'Archiac, Histoire des Progrès, vol. iii. p. 9.	...	...	...	*	*
Calcaire grossier	Muschelkalk	Sierra Morena, Spain	De Verneuil	Bull. Soc. Géol. France, 2e série, vol. xiii. p. 691.	...	*	...	...	...
Eocene sandstone	Coal-measures	Alabama	Tuomey	Geol. Report, Alabama, p. 164	...	...	*	...	...
Eocene (Nummulitic)	Silurian	Sardinia	Della Marmora	Voyage en Sardaigne, vol. i. pp. 228, 233, 245.	...	...	...	*	*
Tertiary	Chalk	Pyrenees	Lyell	Principles of Geology, p. 187.	...	...	...	*	*
Tertiary breccia	Silurian	Sardinia	Della Marmora	Voyage en Sardaigne, vol. i. p. 32.	...	...	...	*	*
....	....	Ootatoor, India	Blanford	Palæontologia Indica, vol. i. p. 6.	...	...	*	...	...
Chalk	Trias	Yorkshire	Lyell	Principles, p. 186	...	...	...	*	*
Chalk	Trias	Spain	De Verneuil	Bull. Soc. Géol. France, 2e série, vol. xiii. p. 678.	...	...	*	...	...
Chalk	Upper Carboniferous	New Mexico	James Hall	Report, Mexican Boundary, vol. i. pp. 128.	...	...	*	...	...
Chalk	Coal-measures	Alabama	Lyell	Visit to North America	...	...	*	...	...
Chalk	Carboniferous Limestone	Russia	Murchison	D'Archiac, Histoire des Progrès, vol. v. p. 352.	*	...	...	...	...
Chalk	Silurian	Spain	C. de Prado	Bull. Soc. Géol. France, 2e série, vol. xi. p. 337.	...	...	*	...	...

Upper Greensand	Laurentian	New Jersey	Cook	Report, Mexican Boundary, vol. i. p. 128.	...	...	...	*	*
		Tarentaise	Favre	Bull. Soc. Géol. France, 2e série, vol. v. p. 262.	...	...	*	...	...
Oolite	Coal-measures	Gloucestershire	Ramsay	Mem. Geol. Survey Great Britain, vol. i.	...	...	...	*	*
	Carboniferous Limestone	Wales	De la Beche	*Ibid.* vol. i. p. 269	...	...	...	*	*
Lias	Coal-measures	France	Ebray	Bull. Soc. Géol. France, 2e série, vol. xx. p. 297.	...	...	...	*	*
	Metamorphic series	Scotland	Geikie	Quart. Journ. Geol. Soc., vol. xiv. p. 3.	*	...	...	*	*
	Silurian	Belgium	Gosselet	Bull. Soc. Géol. France, 2e série, vol. xviii. p. 514.	...	...	...	*	*
Middle Lias	Granite	France	Ebray	*Ibid.* vol. xvi. p. 427	...	...	(fault.)		...
	Quartzite	France	De Beaumont	Explic. Carte Géol. de la France, vol. ii. p. 13.	...	...	*	...	...
Trias	...	...	Lyell	Principles, p. 187	...	...	...	*	*
Lower Trias	Coal-measures	Limousin, France	De Beaumont	Explic. Carte Géol. de la France, vol. i. p. 619.	...	...	...	*	*
Permian	Devonian	Coniri, South America	D. Forbes	Quart. Journ. Geol. Soc., vol. xvii. p. 38.	...	...	*	...	...
	Carboniferous Limestone	Bohemia and Poland	Murchison	D'Archiac, Histoire des Progrès, vol. iii. p. 135.	...	...	...	*	*
		Iowa	Hall	American Journal of Science, 2nd series, vol. xxiii. p. 196.	...	...	...	*	*
		Arctic Seas	Haughton	M'Clintock's Voyage, Appendix.	...	*	...	...	...
		Alabama	Tuomey	Geol. Report, Alabama, p. 80.	...	...	*	...	...
		Nova Scotia	Lesley	American Journ. of Science, 2nd series, vol. xxxvi. p. 189.	...	...	...	*	*
		North Illinois	Hall	Tract on Mississippi Limestone, p. 19.	...	...	*	...	...
Coal-measures	Silurian	North of England	E. Forbes	Quart. Journ. Geol. Soc., vol. ix. p. lxx.	...	...	*	...	...
		Salt Lake, Rocky Mountains.	Hall	Tract on Mississippi Limestone, p. 19.	...	...	*	...	...
		Thüringerwald	Murchison, &c.	Quart. Journ. Geol. Soc., vol. xi., pp. 412–417.	...	...	*	...	...
		West Scotland	Geikie	*Ibid.* vol. xvi. p. 318	...	...	*	...	...
		Texas	Shumard	Bull. Soc. Géol. France, 2e série, vol. xviii. p. 216.	...	*	...	...	...
					2	6	15	17	17

TABLE B (*continued*).

Roof.	Floor.	Locality.	Author.	Reference.	Roof and Floor: Conformably Inclined.	Roof and Floor: Horizontal.	Roof and Floor: Unconformably Inclined.	Floor Inclined.	Roof Horizontal.
					2	6	15	17	17
Coal-measures	Primordial	Texas	Shumard	American Journ. of Science, 2nd series, vol. xxix. p. 124.	*	...	...	...	...
	Longmynd	Shropshire	Ramsay	Lecture at Royal Instit. 1858.	...	...	*	...	...
Millstone-grit	Silurian	Alabama	Tuomey	Geol. Report, Alabama, pp. 37, 38.	...	...	*	...	...
		Sardinia	Della Marmora	Voyage en Sardaigne, vol. i. p. 97.	...	...	*	...	...
Carboniferous	Silurian	Sardinia	Della Marmora	*Ibid.*	...	...	*	...	...
Carb. Limestone	Metamorphic	Rocky Mountains	Hall	Tract on Mississippi Limestone, p. 19.	...	...	*	...	...
Chemung Group	Silurian	Missouri	Shumard	Geol. Report, Missouri, p. 184.	...	...	*	...	...
Devonian	Primordial	Spain	C. de Prado	Bull. Soc. Géol. France, 2e série, vol. xviii. p. 517.	*	...	...	...	...
Old Red Sandstone	Lower Silurian	Czarskoe-celo, Russia	Murchison	Geology of Russia, vol. i. p. 32.	...	*	...	...	...
Devonian	Metamorphic	Basse Loire	Bureau	Bull. Soc. Géol. France, 2e série, vol. xviii. p. 789.	*	...	...	...	...
Lower Helderberg	Utica Slate	Montreal	Hall	Palæontology of New York, vol. iii.	*	...	...	...	...
Middle Silurian	Granite	Sardinia	Della Marmora	Voyage en Sardaigne, vol. i. pp. 60 *et seq.*	...	...	*	...	...
					6	7	22	17	17

the effects of the elements and of time, are obvious; so that, without dwelling on them, I will proceed to remark on the various positions they assume towards each other. These relations have been stated by the original observers in fifty-two cases, and they have been now collected, for examination and use, into the form of a Table (B), which contains their locality, the horizon which they occupy, the authority, and, lastly, the positions of basement and roof.

Table B shows that all the gaps are the products of disturbance. In the six cases where the top and bottom strata are at the same time conformable and inclined, the force must have been exerted obliquely and over a large area (Texas to Missouri). In the seven cases where they are both horizontal, the movement must have been vertical, and have affected a considerable region. In the twenty-two cases where the roof is unconformable to the floor, and both are inclined, there must have been more uplifts than one—an action that has giveu rise to the "complex mountains" of Sismonda and Studer.

In seventeen cases the floor is inclined and the roof is horizontal. Here the former represents disturbance; the latter, quiet deposition long afterwards. Two other columns might have been given, but are omitted because it is impossible for the condition to occur which they would represent, namely, for the roof of a gap to be inclined when its base is horizontal; for all upheavals are caused by a force acting from below.

These gaps or blanks are local, both in their origin and in their effects, because oscillation, their governing cause, is itself local and dependent on laws as yet undiscovered. Observation in the field has demonstrated that perturbation is local. We see this in the alternately fresh and marine deposits of Tertiary and Carboniferous times; and even in the celebrated disturbance on the River Onny (N. Wales), where the unconformity vanishes near at hand; and, furthermore, we see it in the Trias of Tuscany lying on Verrucano (Carboniferous), at the baths of San Julio and elsewhere.

If crust-movements be local, so also is the deposit of sediment, in its details, with epochal specialities. To these conclusions Elie de Beaumont*, Murchison†, Edward Forbes ‡, John Phillips §, Barrande ||, D'Archiac, and others have arrived.

With such mere outlines as the foregoing, we must now rest on the great subject of "leaves torn out from nature's volume," as speaks "the old man eloquent" of Cambridge, begging permission, however, in conclusion, to add a few considerations on the importance of missing formations.

1. They constitute a breach in normal stratigraphic sequence resulting from plutonic influences—influences which, although worthy of the most serious consideration, have hitherto received little notice, save from Mr. Hopkins and Sir J. Herschel.

Some idea of their frequency and extent may be gathered from

* Bull. Soc. Géol. France, 2e série, vol. xi. p. 315.
† Quart. Journ. Geol. Soc. vol. v. p. 625; vol. vii. p. 18; vol. viii. pp. 180, 191.
‡ *Ibid.* vol. x. pp. 77, 78. § Geol. Survey Memoirs, vol. i. p. 144.
|| Bull. Soc. Géol. France, 2e série, vol. xi. p. 311.

the foregoing pages; and still more forcibly from the fact, not confined to one region, that 1188 Palæozoic faults (a kindred phenomenon), each half a mile, 3, 10, 20, or 30 miles long, have been seen by the officers of the Geological Survey within the little area of Wales, and striking out in every direction. (See Geological Survey Maps, sheets 36, 37, 59, 60, 74, 75, &c.)

2. We are taught by missing formations that there always have been areas of dry land, because there always have been gaps, and much alike in character; some of the most distinct and protracted of these are Silurian, a formation about whose emergence anywhere there has hitherto been some uncertainty.

3. They yield us, in the vast Laurentian spaces, European and American, the remarkable spectacle of the most ancient land known, witnessing, itself little disturbed, for a length of time which no man can measure, the successive immersions and emersions going on around them, with all their strange and beautiful results. Agassiz, Logan, and others have recognized the greatness of this fact.

4. The great Russian double gap, where the Oxfordian stage (Jurassic) is interposed, more or less directly (and midway), between the widely separated formations, Carboniferous and Cretaceous, is worthy of special attention.

5. Gaps show us multitudinous discontinuities in deposition; seldom from faults, fractures, or igneous outbursts, but simply from oscillations on broad bases, accompanied by the submarine changes which we detect by reference to the laws affecting the distribution of organic life and the nature of the sediment.

6. These gaps occasion a rearrangement of mineral substances, and of organic existences, in favour of the new formation in the act of being deposited in the vicinity, as well as that change of general conditions which must follow emergence.

7. In one direction they are useful in the production of variety; thus preventing that monotony to which nature seems always opposed.

8. In another direction they greatly retard the multiplication and diffusion of life by converting into dry land, or shallows, many wide seas, whose shores and bottoms are the peculiar nurseries of marine creatures.

9. They have caused great destruction of life by disturbing conditions then existing, such as pressure, light, heat, currents, and the like, all necessary to the welfare of plants and animals. In the disturbance which took place in France at the end of the Liassic stage 300 species of Radiata and Mollusca perished *.

10. Being extraordinarily numerous, they lessen the importance of the great rule of gradation from stage to stage in the sedimentary column.

11. At these gaps there is perfect independence, a thorough severance, of the two contiguous beds or formations. Often not a connecting link is left, the floor strewn with the long-since dead being merely the support of the incumbent mass, and nothing more. An impassable barrier has thus been formed to the recurrence or

* D'Orbigny, 'Cours de Paléont.' vol. i. 2^{e} partie, p. 475.

transmission upwards of living beings, improved or unimproved, over surfaces vast and almost innumerable *.

12. The geological record is much obscured by these gaps, and in parts obliterated. The readings must be taken up in different places—obtaining general results only; and this is best done, perhaps, with the aid of the fossils. If these be few and simple (I am not speaking now of individuals), the duration of any given epoch has been short; while a highly elaborated and plentiful population indicates prolongation of time.

13. These gaps or blanks by their magnitude and number become a great feature in the earth's crust, expressive of unity of design in time and space.

* See the striking instance of independence in the Northern Alps, as indicated by the grand rupture and hiatus between the Nummulitic (Eocene) formation and the younger Molasse and Nagelflüh, as explained by Sir R. I. Murchison in his paper on the Alps, Quart. Journ. Geol. Soc. vol. v. p. 304.

Professor Winchell
with the respect of the
Author

[*From the* QUARTERLY JOURNAL *of the* GEOLOGICAL SOCIETY *for February* 1863.]

ON THE

CAMBRIAN AND HURONIAN FORMATIONS.

BY

J. J. BIGSBY, M.D., F.G.S.

Contents.

Part I.—Remarks on the Geographical Conditions of the Cambrian System.

I. *Introduction.*—Some of the following statements, and the conclusions to which they have given rise, were originally intended to refer, in chief, to the presence or absence of organic remains in the Cambrian rocks; but, led on by points of interest that gradually presented themselves, the inquiry has been conducted further than was at first anticipated.

I may perhaps be allowed, for the present, to take for granted that the Cambrian of Western Europe passes conformably upwards into the Silurian series, with certain changes introduced by altered conditions. Usually these two sets of rocks are mutually conformable, and pass into each other, sometimes by insensible gradations *.

It is also true that their unconformity is very frequent, from the local operation of plutonic forces. I shall not stop now to bring forward proofs of these several assertions.

I have given as a Table a synoptical list of all the Cambrian deposits known to me, and also other Tables of some use. On these Tables is grounded much of what is advanced in this paper.

* I ought, however, *in limine*, to say that the published proofs of this connexion between Cambrian and Silurian beds (*some of them at least*) need revision.

II. *Characters of the Cambrian.*—The Cambrian formation is so varied in its particulars, and so familiar as a whole, that a definition of it need not be attempted.

We find in it, however, the following characters:—

§ 1. In Northern and Western Europe alone (or nearly alone) it consists principally of purple and black clay-slates, often chloritic and micaceous, together with conglomerates, grits, and sandstones, placed almost indifferently on any horizon.

§ 2. This schistose constitution is elsewhere absent, except in one or two localities; and usually if any rocks exist intermediate between the Silurian beds and a crystalline base, those rocks are derived from the latter, and have no mineral or palæontological connexion with the Silurian series.

§ 3. *Immediate* contact (transgressive) between the Silurian and the metamorphic rocks may be said to be more general and more extensive than between either the schistose or the simply conglomeratic rocks above mentioned, which are themselves, perhaps, about equal in extent.

§ 4. The Cambrian has a tendency to assume a local character, inclining perhaps to the mixed schistose character mentioned in § 1, the typical form as heretofore considered.

§ 5. The various beds, argillaceous, arenaceous, &c., are inconstant in their succession, *i. e.* they have different horizons; and some may be absent altogether.

§ 6. They vary also in their thickness, both as a whole and in the individual beds.

§ 7. Some of the mineral substances essential to organic structure, such as lime, phosphorus, fluor, azote (?), are absent, except a little of the first, and that rarely.

§ 8. With a large and varied assemblage of highly organized life in the lowest Silurian deposit, we find this older, but kindred set of rocks to be almost totally wanting in evidences of animal and vegetable existence. Such forms as do appear are of low organization, and do not indicate a fauna differing essentially from that of the Silurian scheme: life is not here another, and an original, conception.

§ 9. The Cambrian is not the Huronian.

a. *Typical Form and Distribution.*—The description given in § 1 may be taken as representing very briefly the typical form of the Cambrian as generally understood, and as first seen in Wales by Professor Sedgwick. It has since been traced, with modifications, into Ireland, Brittany, Dép. Loire Inférieure, &c., in France, as well as into Thuringia and Bohemia, and less distinctly in a few other districts.

Many of the leading facts in Cambrian geology may be learnt by consulting the large Table at the end of this part of the paper; and still more satisfactorily by recourse to the original authorities, as set down in the footnote*.

* The principal authorities on the Cambrian Formation are as follows:—
ENGLAND AND WALES.—Professor Sedgwick. Proc. Geol. Soc. and Quart. Journ.

In § 2 a very different state of things is revealed: there is not a shred of Cambrian schist, nor of its grits and peculiar conglomerates, throughout vast spaces in America, as far as is yet known, embracing many degrees of latitude and longitude, throughout the Arctic Seas, Hudson's Bay, North-east America, with Texas, Nebraska, and Wisconsin.

We see the same absence of Cambrian schist through vast breadths of Northern Europe, that is, in Scandinavia, the north-west end of Scotland, and in Sardinia. In fact, the larger part of the schistose rocks of examined countries, though apparently Cambrian, is really Huronian.

From all these countries, as I have said, schists are either altogether absent or extremely rare. Where there is an intermediate mass of rock, it is a conglomerate supporting the Silurian base, and resting transgressively on the crystalline rocks. To take the following cases: a gneissic conglomerate is seen at and about Whitehall, on Lake Champlain, New York, in this position; also on the River San Saba, in Texas; in Nebraska, among the Black Hills; on Granite Island, Black Bay, Lake Superior *; and in the north-west of Scotland and the neighbouring isles.

The mineral constitution of all these conglomerates is much the same, but wholly dependent on that of the rock below. Thus the red Scottish conglomerate is totally derived from the underlying Laurentian rock, and, though in contact, has no mineral connexion with the Silurian above. It is both coarse and fine, and small portions of it are triturated into fine red or purplish sandstone.

Geol. Soc., *passim*; Philosophical Magazine.—Professor Sedgwick and Professor M'Coy. British Palæozoic Rocks and Fossils, 1855.

Great Britain, &c.—Sir R. I. Murchison. Siluria, 2nd edit.; Quart. Journ. Geol. Soc., vols. xvi., xvii., *et passim*.

Wales, &c.—Prof. A. C. Ramsay. Lectures at Government School of Mines; Lectures at Royal Institution; Quart. Journ. Geol. Soc. vol. ix. pp. 162, 172; Geologist, vol. i. p. 171.—W. T. Aveline, Esq. Geol. Survey Sections, sheets 36, 37.—J W. Salter, Esq. Quart. Journ. Geol. Soc. vol. xii. p. 246, and vol. xiii. p. 200.

Scotland.—G. Tate, Esq. Geologist, 1860, p. 240.—D. Page, Esq. Brit. Assoc. Rep. 1858.—Professor Harkness. Quart. Journ. Geol. Soc. vol. viii. p. 393; vol. xii. p. 239.—Professor J. Nicol. Quart. Journ. Geol. Soc. vol. xiii. p. 17.

Ireland.—J. B. Jukes, Esq., and Messrs. Wylie and Kinahan. Journ. Dublin Geol. Soc. vol. v. &c.

France.—MM. Elie de Beaumont et Dufrénoy. Explic. de la Carte Géol. de France, pp. 130, 158, 204, 251.—MM. Lorieux et de Fourcy. Carte Géologique de Morbihan.—MM. Dalimier. Bull. Soc. Géol. France, N. S., vol. xviii. p. 664; Comptes Rendus, vol. xlvi. p. 636 (Cotentin and Pyrenees).—MM. de Verneuil, d'Archiac, Rouault, Triger, &c.; also Siluria, 2nd edit. p. 444.—Rozet, Ardennes.

Alps.—MM. von Hauer et Fœtterle. Annales des Mines, 5me sér., vol. viii. p. 130.

Germany.—Barrande. Syst. Sil. de Bohème; Bull. Soc. Géol. Fr. vol. viii. &c. &c.—Sir R. I. Murchison and Professor J. Morris. Quart. Journ. Geol. Soc. vol. xi. pp. lvi, 412.

S. America.—D'Orbigny. Cours de Paléontologie, pp. 111, 169.

N. America.—Roemer. Bull. Soc. Géol. Fr., N. S., vol. xviii. p. 216.—B. F. Shumard. Bull. Soc. Géol. Fr., N. S., vol. xviii. p. 220.

* Sir W. E. Logan, Geol. of Canada, 1862, p. 78.

These conglomerates and sandstones, sometimes 1500–3000 feet thick, are local; and they are called Cambrian because they occupy the place of that formation in the geological series; but they have no affinity with the Cambrian of Wales, for, both in Europe and America, they are merely the re-cemented fragments of the crystalline rock on which they repose. The sàme is to be said of the bed near Kinnekulle, in Sweden, which lies between the granitic gneiss there and the Silurian strata; it consists in like manner of re-adhering fragments of the metamorphic rock below—the "arkose" of Brongniart. These are important facts, and they derogate not a little from the high rank at present held by the Cambrian as a system.

The schistose form of Cambrian and the local puddingstone variety do not form constant and widely diffused strata, like those of many kinds of rocks in the palæozoic and mesozoic series, the conglomerate being native, the other comparatively foreign.

According to our present information, the *direct* superposition of Silurian upon metamorphic rocks, mentioned in § 3, prevails over considerably more space than the schistose or conglomeratic intermediates. We find them in close adhesion for 2000 miles, from Labrador westward to Minnesota beyond the Mississippi River. At a multitude of points along this line they have been examined by Logan, Murray, Chapman, Richardson*, myself, and others,—on the shores of Labrador, Lake St. John (L. Canada), near Quebec, Montreal, Kingston, Lake Simcoe, on the Great Lakes, and so on.

Professor Haughton, in the Appendix to M'Clintock's 'Fate of Sir John Franklin,' broadly states that "the Silurian rocks of the Arctic Archipelago rest *everywhere directly* on the granitoid rocks, with a remarkable red sandstone, &c.;" and, I suppose, transgressively, seeing that the Professor finds the Upper Silurian beds there to be horizontal. The same immediate contact takes place in the Appalachians and on the Upper Mississippi†.

In the excellent account of the geology of Bolivia and Southern Peru, by David Forbes, Esq., F.R.S.‡, the word "Cambrian" never occurs. Silurian beds of enormous thickness, with *Cruziana Boliviana* and Annelid-tracks, are said to rest directly on granite. Nor does the Cambrian show itself in either of Mr. Forbes's two sections (335 and 328 miles long respectively) through these countries, abounding in palæozoic strata. In the neighbouring province of Chiquitos M. d'Orbigny observed the same facts; and also on the flanks of the lofty Illimani, a part of these Cordilleras §.

This direct contact obtains also in Scandinavia, as at Andrarum, &c., in Scania, and in the Silurian trough of Christiania, Norway ||. As regards Bohemia, M. Barrande expresses himself very satisfactorily on this point in 'Bulletin Soc. Géol. de France,' n. s. vol. x.

* Logan and Murray, Geol. Reports, *passim*; Chapman, Canadian Naturalist; Richardson, Geol. Reports, Canada, 1857, p. 78.

† Rogers and D. D. Owen, Reports on Pennsylvania and Minnesota.

‡ Quart. Journ. Geol. Soc. vol. xvii.

§ Travels in South America, vol. iii. pp. 146, 225.

|| Sir R. I. Murchison, Quart. Journ. Geol. Soc. vol. xi. p. 162.

General Portlock, also, states* that in Londonderry coarse arenaceous schists, containing *Orthis grandis*, &c., rest directly upon, and skirt granite and hornblende-rock (see section, p. 230). Mr. Jukes observed a similar fact among the Cambrians of Wicklow † (see section); and Professor Ramsay informs me that he has seen it in Scotland.

b. *Stages in the Cambrian Epoch.*—The Cambrian epoch then is marked by three distinct conditions, which perhaps represent stages caused by changes in the relative level of land and sea; and hence the want of constancy in its constituents.

These conditions are :—

1. The under rock, Laurentian or Huronian, having been exposed above water, no deposit whatever took place until the Primordial epoch of the Silurian period arrived; in some places with abundance of life.

2. The parent rock having been submerged in shallow and disturbed waters, native conglomerates were produced by well-known processes (Scotland, North America, &c.).

3. These parent rocks having subsided into great depths, arenaceous, argillaceous, and other deposits took place, sometimes to the thickness of 25,000 feet and more; such deposits becoming afterwards more or less metamorphosed.

c. *Stratigraphical characters.*—Passing by § 4, we find in reference to § 5, on examining the Synoptical Table, that the succession of beds in this group of strata (schists, grits, conglomerates, &c.) is quite irregular. This arises from local causes; and the want of stratigraphical agreement, it is remarkable to notice, is as strong in contiguous districts as in those more remote.

In considering § 6, which treats of the thickness of the Cambrian strata, I believe that unusually great accumulations have no great geological importance. I deduce from them that a change of level has occasioned heavy denudations somewhere, followed, of course, by loaded currents, which have been suddenly arrested at the place of accumulation. One effect is, that this thick deposit has few or no fossils, for more than one obvious reason. We see this exemplified by the ten or twelve thousand feet of Devonian Sandstone (without organic remains) in Kerry and Cork, Ireland‡; and in the three thousand feet of the same rock, forming the Catskill Mountains, New York, containing few animal remains, but many plants. The thickening of the middle Carboniferous Limestone in Derbyshire and Yorkshire is another similar instance. We must not, therefore, exaggerate the importance of thickening in the Cambrian.

d. *Organic elements.*—As regards § 7, the absence from this set of beds of phosphorus and such elements is generally believed, but upon what authority I know not. Instead of numerous analyses in support of this opinion, I only recollect a very few by Mr. D. Forbes and by Dr. Lyon Playfair. But we must not forget Professor Daubeny's

* Survey of Londonderry, p. 303.
† Jukes and Wylie, Journ. Dublin Geol. Soc. vol. vi.
‡ Jukes, Student's Manual, p. 409.

curious experiments, which consisted of sowing barley in powdered rocks; he found that whatever might be the age of the rock, provided only that it belonged to a series in which organic remains were present, the amount of phosphoric acid present in the crop exceeded considerably that existing in the barley from which it was derived. In Cambrian rocks Dr. Daubeny found no trace of phosphorus.

We know that calcareous matter in Cambrian beds seldom occurs, and only in small infiltrations, as in Wales, or in a thin and solitary seam, as in Brittany. Where one or more large calcareous beds, unfossiliferous, are observed in a group which seems to belong to this epoch, the strong probability is that it belongs to the Huronian series.

e. *Paucity of Fossils.*—We also know that § 8, marking the impoverished life of the Cambrian, contains an important fact which we are authorized to state, after a most pertinacious and skilful examination of its beds, in Wales and Ireland especially. Nor need we expect any traces of life in the contemporary conglomerates of Scotland and America.

The frequent occurrence of conglomerates, grits, and sandstones in this series forbids our attributing the absence of life in it to any permanent abyssal depths, as was supposed by the late justly lamented Daniel Sharpe*.

The remains of organized beings in the Cambrian are few, both generically or specifically, and they are mostly related to certain low forms in the primordial zone of various countries; for instance, the *Arenicola didyma*, which corresponds to the *Scolithus* (Annelid-tubes); *Palæopyge Ramsayi*, corresponding to the Trilobite (a high form, however); the *Oldhamia* is a sea-weed (Goeppert); the plant *Chondrites* occurs also in the Silurian as a genus†.

I repeat, then, that in this period we are not introduced to any set of living creatures wholly unknown in later periods, as we are in some other parts of the great sedimentary succession.

Some of the reasons for the absence of organic remains from this group of beds may be stated as follows:—

1. The general absence of carbonate of lime, and the probable absence of phosphorus and other elements of organization.

2. The great, continued, and occasionally tumultuary deposition of sediment, in which few or no animals could have lived (James Hall).

3. The deposition of substances unfit to support life, whether directly poisonous or because consisting of any unmixed material, as clay, lime, silex, &c.

4. Plutonic action, which was frequent in the Cambrian, operated by modifying or destroying rocks and their contents; metamorphism, which need not have been caused by subterranean heat, has the same effect.

5. Shells in porous or permeable strata are often removed by the infiltration of solvent fluids‡.

* Quart. Journ. Geol. Soc. vol. ii. p. 208. † *Ibid.* vol. xii. p. 246.
‡ See Mr. Prestwich's remarks, *ibid.* vol. viii. p. 245.

However we may seek to account for the absence of a varied fauna in the Cambrian strata, the fact is rendered the more remarkable by the occasional abundance of the phosphates, sulphates, and fluates, as well as of graphite, in the Silurian basement-rocks, which immediately followed the Cambrian by tranquil deposition.

III. *Abundance of Life above the Cambrian.*—Not a few naturalists are inclined to believe that in the *molluscan* form of life, from the earliest times, instead of an ascendant movement in their order of development, a decadence even has affected them; and that these organisms of distant date do not yield in specialization to the like forms of today. A tendency to concur in such opinions may well arise from a consideration of the following facts, which show at the same time how abrupt and great must have been the change from life in the subjacent strata, to life in the Silurian; from a state, that is, of great comparative sterility, to one singularly prolific.

a. *Tracks of Crustaceans.*—First, the occurrence in the Potsdam Sandstone (the oldest Silurian) about the mouth of the Ottawa, that noble river, and about Lake Louis into which it flows, of footprints and tracks of several species of large Crustaceans. They have been faithfully described by Sir W. E. Logan and Professor Owen, besides having been most generously illustrated by the former. These appearances carry the existence of complex forms of life very far down.

b. *Phosphatic Coprolites with Lingulæ.*—Secondly, while James Hall, the great palæontologist of America, found in the Delthyris Shaly Limestone (Upper Silurian) coprolite-like, phosphatic nodules, full of crushed *Lingulæ*, the Geological Commission of Canada met with facts more remarkable still. They discovered that a large breadth of country on the Ottawa River, from Lake Allumettes to, at least, Grenville, a distance of 80 miles in the south-east direction, is more or less sown with coprolites in calciferous sandstone. This rock, at the Falls of the Allumettes, is a conglomerate, and rests directly on Laurentian gneiss.

These coprolites are sometimes $2\frac{1}{2}$ inches long by $\frac{1}{2}$ an inch broad, and are filled with a large species of *Lingula*; in one case a fragment of this shell was found lying crosswise in the nodule. Besides the *Lingulæ*, a few *Pleurotomariæ* or *Holopææ* are met with in these reniform masses.

The Grenville coprolites are smaller and more compact than those of Lake Allumettes. They give off an animal odour when heated, and principally consist of phosphate of lime, as do those of the Township of Hawksbury, close by. These latter are yellowish brown, and smell like burnt horn when heated. Dr. Lyon Playfair proved that similar bodies from the Bala Limestone, in North Wales, were foreign bodies of animal origin*. All phosphatic nodules may not be coprolites; but these from the Ottawa have every appearance of being so.

The coprolites of Lake Allumettes, &c., seem to be the excretions of

* Quart. Journ. Geol. Soc. vol. vii. p. 267.

large animals, and are probably those of the large Crustaceans whose footprints have just been alluded to. So that we may now-a-days have some small perception of the antique and mysterious interest which is attached to these relics, dragged out of the abysses of time by a young science.

D. D. Owen and others after him have mentioned, with great surprise, the countless myriads of phosphatic *Lingulæ* buried in the Potsdam Sandstone which forms the walls of the River St. Croix, in Minnesota, not far from its junction with the Mississippi. In the same way Trilobites in incalculable numbers occupy a bed of Trenton Limestone at Beaufort, Quebec; all in fragments, and lying flat upon each other.

c. *Primordial Zone.*—I have, finally, to request your attention to the great and unexpected abundance of life in the Primordial rocks, the immediate successors of the inhospitable Cambrian.

About ninety genera of Mollusca, and 250 species (allowing for regional duplicates) met with regionally, are found in this one set of beds (called indifferently Potsdam Sandstone, Lingula-flags, Primordial zone, or, as I believe, Taconic). The Molluscan orders and genera are well represented in this initiatory basement-bed, even up to the most highly organized—excepting the *Cephalopoda*, which are entirely absent.

In this Primordial zone alone, there are twenty-five genera of Trilobites, and 114 species; seventy-three species have been found in Scandinavia alone, partly because this region has been thoroughly examined (by Angelin).

It must be remembered that vast spaces of the earth's surface have received no attention, and that extensive Silurian districts, such as Russia, Germany (exclusive of Bohemia), Scotland, and Sardinia, have as yet furnished not one indisputable basement-fossil; while from others, Australia, France, Spain, we have received but one or two.

We cannot but feel and express great astonishment to see a rich and well-balanced fauna thus spring forth from a Cambrian barrenness which was nearly absolute, and with a quickness not yet fully explained. Indeed this barrenness is in all probability more apparent than real, for, according to Mr. Salter, we are dealing with shore-deposits only, which generally present few species. There may have been, and probably was, a deep-sea fauna*.

All that has now been stated may well prepare our minds to recognize a living nature in the Laurentian, or fundamental gneiss-rocks, equally diversified and plentiful. We may not have found, at this moment, the very forms themselves, but their residuary elements are there in vast abundance.

* With a group or commonwealth of living creatures in the Primordial zone, so well furnished and peopled in every department of Molluscan life, some requiring deep or shallow waters, some only flourishing in moist sands or tangled seaweed, and others on rocks above low water, is it not probable that the universal, shallow levels frequently attributed by continental authors to the earliest Silurian period have only existed in imagination?

TABLE II.—*General Summary of Primordial Fossils.*

Countries.	Authors.	GENERA.												SPECIES.											
		Cephalopoda.	Gasteropoda.	Pteropoda.	Brachiopoda.	Crustacea.	Annelida.	Cystidea.	Bryozoa.	Zoophyta.	Incertæ sedis.	Fucoids.	Total.	Cephalopoda.	Gasteropoda.	Pteropoda.	Brachiopoda.	Crustacea.	Annelida.	Cystidea.	Bryozoa.	Zoophyta.	Incertæ sedis.	Fucoids.	Total.
Spain	Casiano de Prado	...	1	..	3	5	...	1	...	...	...	1	11	...	2	...	5	8	...	1	...	...	...	...	16
Sardinia	Della Marmora	Omitted, but existing.																							
France	De Verneuil	...	...	...	1	...	...	...	...	...	...	...	1	...	...	...	1	...	...	...	...	...	...	...	1
England and Wales	Murchison, &c.	...	...	...	2	7	1	...	...	...	...	1	11	...	...	...	3	8	2	...	...	...	1	...	14
Scotland	Murchison, &c.	None?																							
Ireland		None.																							
Germany		Not known.																							
Bohemia	Barrande	...	...	1	2	7	...	3	1	...	2	1	17	...	...	...	2	27	...	4	6	...	2	1	42
Russia	Murchison, &c.	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	1
Scandinavia	Kjerulf, Angelin	...	...	...	5	12	...	...	1?	...	...	...	18	...	...	...	8	73	...	...	2	...	...	...	83
Australia	Selwyn	...	...	...	1	...	...	...	1	...	...	...	2	...	...	...	1	...	...	...	1	...	...	...	2
Quebec, N. A.	Billings	2	7	...	6	8	...	...	?	2	...	...	25	9	21	...	9	22	...	...	30	...	...	...	91
Straits of Belleisle, Newfoundland	Billings	...	...	1	1	2	...	...	...	2	...	2	8	...	...	3?	5	3	...	...	...	...	...	2	13
Vermont, U. S.	Billings	...	...	...	2	1	...	...	...	...	...	1	4	...	...	...	2	4	...	...	...	...	...	1	7
New York	Hall, &c.	1	6	1	2	7	1	.	...	...	...	1	19	1	12	1	4	7	1	...	...	...	...	3	29
Pennsylvania	H. D. Rogers	...	...	...	2	...	1	...	...	...	...	1	4	...	...	...	2	...	1	...	...	...	...	1	4
Tennessee	Safford	...	...	...	...	1	1	...	...	...	...	...	2	...	...	...	...	1	1	...	...	...	...	...	2
Texas	Roemer, Shumard	...	...	...	5	5	...	...	...	...	...	...	10	...	...	...	5	6	...	...	...	...	...	...	11
Wisconsin	Hall, &c.	...	...	1	3	6	1	...	1	...	...	1	13	...	...	1	2	8	1	...	1	...	...	1	14
Nebraska	Hayden & Meek	...	...	...	3	2	...	...	...	...	...	...	5	...	...	...	3	2	...	...	...	...	...	...	5
Total		3	14	4	38	63	5	4	4	4	2	10	151	10	35	5	52	169	6	5	40		3	10	335

…, pp. 37 & 38.

1. WALES…	…ND.	5. IRELAND.
From Menai Straits ove… to the North of Snowdo…	Quart. Journ. 360. Sir R. I. …t. Journ. Geol.	Wicklow, Wexford, and Dublin Counties.
Prof. Ramsay, Horiz. … Survey of Great Britain…	…. Coast, Quart. xvi. p. 219. …oss-shire, Quart. xvii. p. 175.	Messrs. J. B. Jukes & Wyley, Journ. Geol. Soc. Dublin, vol. vi. p. 28.
Grit …………………… Slate …………………… Grit …………………… Slate …………………… Slate and grit ………… Grit and conglomerate … Conglomerate and grit, …	*…lands.* …ne, } 2000–2500 feet. grey, with red *…ath.* …d, hard. …acent gneiss. *…oast; also Isle of …ss-shire.* …bbles of the rock	Chiefly green and purple grits, shading off into quartz-rocks. Grits, bright red, green, grey, coarsely granular, hard. Sandstones, compact, close-grained, white mica-flakes occasionally. Slates, green, red, olive-brown, yellowish, often chloritic, or a fine roofing-slate or flagstone. (Stratification very confused.) These rocks are identical with those of Barmouth, Wales.

6. FRANCE…	…MERICA.	10. AUSTRALIA (?).
Cotentin? (Norman… Dalimier, Bull. Soc. G… vol. xviii. p. 664. Granville, Cancale, &c… Bull. Soc. Géol. Fr. n. s. … Ardennes, Slate-qua… mogne. Rozet et Dumo… mont et Dufrénoy, Expl… Géol. de France.	…nba. B. F. Shu- …Fr. n.s. vol. xviii. Hayden, Trans. …ol. xii. p. 23, &c.	Victoria, on Rivers Loddon and Campaspe? A. Selwyn, Quart. Journ. Geol. Soc. vol. x. p. 299.
Cotentin? (Norman… Sandstone, compact, in… Sandstones, purple. Conglomerate, felspath… Limestones, thin. Clay-slates at St. Zo. Schists, micaceous and s… Schists, macliferous. *Granville, Canca…* Schists, macliferous, w… and conglomerates. *Ardennes (Rim…* Quartzite, thick-bedded. Psammite, alternating, t… Schists, pale. Schists, shining; thickn… Schists, argillaceous and…	granitic, 150 ft. …unted by fossili- …ndstone.) *…a.* …ian. …ests extensively … on Azoic (Hu-	Sandstones, ferruginous, micaceous. Grits, felspathic, red, grey, brown. Slates, clay, arenaceous, felspathic. Flagstones, fine arenaceous. Quartz-rock } alternating. Conglomerate } Direction N. and S., dip high. Gold in quartz-veins. No organic remains. Thickness 35,000 feet. (N.B. Probably Lower Silurian.)

Part II.—The Huronian Formation of Canada not Cambrian; with Remarks on its Regional Affinities.

I. *Introduction.*—The Huronian formation, one of the several great discoveries of the Geological Commission of Canada, will probably be found to be an important member of the fixed rocks of the earth; for on the north side of the Great Lakes of Canada, where it was first detected, it occupies a district 710 miles long, and there is a considerable area of it on the south-east side of Lake Superior. It is largely and variously developed also in Norway, and probably in other parts of Europe.

This set of rocks is therefore of great importance, geologically as well as economically, and is fully entitled to be called a formation if we adopt Deshayes's definition of the term, that is, " a certain number of beds laid down under the influence of the same phenomena"*.

The general feeling of geologists† is that the Huronian of Canada is the same as the Cambrian of Western Europe; but careful examination into all the circumstances seems to provoke more than a doubt as to the correctness of this view.

No true Cambrian exists in North America according to Dana‡; and, as far as my experience goes, the Huronian constitutes a group of beds which may be said to be its substitute in place, if not in time. It has received a name from Sir W. E. Logan because it has a new and distinct character, and needed a designation; and by him and Mr. Murray, his able and enterprising coadjutor, it has been minutely described.

No Cambrian in N. Am. Dana.

As I have paid three visits to the greater part of this formation, in Canada, I may be permitted to make the following brief comments upon it; my object being, first, a summary account of its place and relations, with some small additions of my own; secondly, to point out an all but perfect identity in the members of this formation in Europe and America; and thirdly, to show that it is not Cambrian.

II. *Characters of the Huronian.*—a. *Geological position.*—The Huronian of Canada occupies a stratigraphical horizon not far from that of the Cambrian of Wales, between the Laurentian gneiss and the Silurian; but it is older, for the Cambrian is continuous into, and conformable to the base of the Silurian, when the latter is in an undisturbed and normal state, while the Silurian is invariably transgressive as regards the Huronian formation in both hemispheres. I have seen this exemplified in numerous instances in Lake Huron and Lake Superior. That the traces of life are not found in this formation affords but moderate aid in fixing its date, for this happens

* Deshayes, Bull. Soc. Géol. de France, N. S., vol. ii. p. 89.

† Sir W. E. Logan, American Journ. Science, N. S., vol. xiv. p. 227. Sir R. I. Murchison, Siluria, 2nd edit. p. 19. Coquand, Traité des Roches, p. 299. D'Archiac (as I understand), Bull. Soc. Géol. de France, N. S., vol. xviii. p. 664. Morris, Geologist, vol. i. p. 139.

‡ Dana (Address, Rhode Island), Canad. Journ. 1855, p. 386.

§ At the Twin Falls, River Menomonee, south side of Lake Superior; see Foster and Whitney, Geol. of Land District, p. 24. Also between the Rivers Missassaga and St. Mary, Lake Huron; see Sir W. E. Logan, Geol. of Canada, 1862, p. 56.

in all the stages of the sedimentary series; and the not uncommon marks of ripples, cracks, and mud-flows§ in its quartzites and fine grits render it possible that signs of animal or vegetable existence may eventually be met with. Neither do we learn much from its extraordinarily agitated and metamorphosed condition in many places, for the same may occur at any epoch.

b. *Geographical distribution.*—The geographical position of the true Huronian beds may be broadly stated in the following words.

With a breadth often small (10–20 miles), but often concealed by jungle and morass, the northern mass extends 710 miles, as already stated, along the north-west watershed of Upper Canada, and principally along the borders of Lakes Huron and Superior. We trace it for 150 miles from near Lake Tematscaming (R. Ottawa), 80 miles north-west of Lake Nipissing, south-westwards, to Shebahahning, on Lake Huron; and from thence westward for 120 miles to Gros Cap, in Lake Superior. From this well-marked headland, northerly and westwardly, the whole edge or coast of the latter lake, with small and uncertain exceptions, consists of this formation as far as the Pigeon River, near Grand Portage, about 440 miles; and it is amply exposed by the bare and hilly nature of the country *.

Another aggregate of these beds occupies more than 3000 square miles of the region south-east of Lake Superior, on the River Menomonee (a tributary of Lake Michigan), and the districts north and west of that river. It is an area of very irregular shape, 80 miles wide in one place, and having its highest points 1800 feet above the sea-level †.

There is good reason to believe, according to my own recorded observations, that the only three contiguous lakes in South Hudson's Bay at all known geologically—the Lacroix, Lapluie, and the Lake of the Woods—each a few hundred miles round, consist largely of this formation. Besides being extensively developed in the Adondirock Mountains of the State of New York, and probably also in Missouri and Arkansas, the Huronian is seen to great advantage in Norway, and is not wanting in France; but of its occurrence in these countries more will be found in the sequel.

c. *Lithological characters and typical form.*—Table III. is a Synopsis exhibiting the leading features of the Huronian beds, wherever they are known with tolerable certainty. It enables us to keep facts separate and distinct from suppositions.

For the minuter details, the several authorities named in the foot-notes may be consulted ‡. Of these I am most indebted to the minute and truthful reports of the Geological Commission of Canada; but my obligations to the other investigations are neither few nor small.

By reference to the Synopsis (Table III.) at the end of this paper, it appears that, on the large scale, the characteristic beds of

* Sir W. E. Logan, Geol. of Canada, 1862; Murray, Canadian Reports.

† Foster and Whitney, Geol. of Land District of Lake Superior, p. 31.

‡ Sir W. E. Logan, Geology of Canada, 1862, p. 50, &c. Alexander Murray, Geological Reports of Canada, 1849, 1857, &c. Thomas McFarlane, Canadian Naturalist, &c., vol. vii. p. 1. Foster and Whitney, Geology of Land District, Lake Superior. Durocher, Mémoires de la Société Géol. de France, vol. vi.

the Huronian formation in America, whether in Canada, Wisconsin (U. S.), or elsewhere, consist of:—

1. Slate; chloritic, siliceous, and hornblendic.
2. Slate; conglomeratic, matrix impurely argillaceous; the pebbles and boulders being granitic, syenitic, and slaty.
3. Conglomerates; quartzose, with white quartzose and red jasper pebbles.
4. Trap and pale greenstone, both conformable and intrusive.
5. Granite; red, moderately porphyritic, intrusive.
6. Crystalline limestone; with some serpentine.

All these rocks are set down in the order of their abundance, the most prevalent first; Nos. 2 and 3 being very thick compared with the other beds individually, *i. e.* 7900 feet out of 16,700 feet (between the Rivers St. Mary and Missassaga, Lake Huron*), if we add up the separate beds.

d. *Connexion with the Laurentian.*—The connexion of the Huronian set of rocks with the Laurentian is not so fully made out in America as in Norway; but we are not without some good materials, and time will do the rest. Sir William Logan met with a conformable junction of these two formations on the River Kaministiquia, on the north side of Lake Superior, in the rear of Fort William. At the lower end of the Second Portage, above the Grand Falls, the Laurentian appears as a massive syenite or, rather, as a hornblendic gneiss. Resting on it conformably, there occurs a series of dark, greenish-blue or greenish-black slates (Huronian); the one rock almost running into the other. The section extends for a quarter of a mile along the river-bank. The Huronian has been observed to rest on granite in two places,—on Spanish River in Lake Huron, and again on the same granite 100 miles to the west, near Gros Cap, on Lake Superior†.

No particular succession of individual beds has been, as yet, made out, either in Europe or America; not but that there are, in parts, long lines of distinct stratification, but because there are scarcely any dips to be depended on. On Lake Huron, in the district just mentioned, this may well happen, through the occurrence of two enormous downthrows in a wild and marshy country; and then again from the inextricable confusion created by the violent intrusion of molten rocks at five distinct epochs‡, the last of which produced large deposits of copper-ores.

e. *Igneous intrusions.*—Any description by words of the mutual penetration, interweavings, and delicate inosculations of bright-green greenstone and red granite, over considerable spaces of the mainland, between the Rivers Missassaga and Thessalon, has been abandoned in despair by Mr. Murray§. And Messrs. Foster and Whitney have been equally foiled by similar blendings of granite and greenstone on the Menomonee, between Sandy Point and Sturgeon Point||.

* Murray, Canadian Geological Report, 1858, p. 76.
† Canad. Geol. Report, 1849, p. 8.
‡ Murray, Report on North Shore of Lake Huron, 1849, p. 14.
§ Canad. Geol. Report, 1858, p. 76.
|| Foster and Whitney, Geol. Surv. of Lake Superior Land District, 1851, p. 19.

Many years ago I published in the 'American Journal of Science' a coloured representation of these capricious mutual infoldings on the east of the mouth of the Thessalon River (Lake Huron). In the middle, too, of a naked islet in Lake Huron, opposite the river just mentioned, but three miles off, a boss of granite pushes its bare red mass from beneath a paste-like envelope of fine-grained greenstone, just as occurs in Carp River, on the south side of Lake Superior*, but the mode of contact is not stated.

III. *Huronian of various districts.*—a. *South shore of Lake Superior.*—With respect to the Azoic Series of the south shore of Lake Superior, already alluded to, I beg to refer the Society to columns 8, 9, and 10 of Table III., and here quote Foster and Whitney† as saying that this series "is in alternating beds, of great thickness, of gneiss, of chloritic, talcose, argillaceous, and siliceous slate, of quartz, of saccharoid and crystalline limestones, and serpentines—all much contorted, highly inclined—nowhere having a sedimentary aspect, and most metamorphic near the lines of igneous outburst," so powerful and numerous hereabouts.

I look upon the Huronian or Azoic Rocks, here spoken of, as belonging to the Huronian of the north of Lake Huron and Lake Superior, for the following stratigraphical and mineralogical reasons:

1. The transgressive relation of the Potsdam Sandstone to both.
2. The same strike East and West in both; dip high.
3. The great prevalence in both of chloritic, dioritic, and hornblendic slates.
4. The abundance of trappean and hornblendic rock, sometimes in brecciated masses composed of jasper, slate, felspar, and hornblende.
5. The extraordinary and extensive intermixture of the beds of greenstone and granite, which defy description and classification.
6. The same quartzites, occasionally becoming a conglomerate, with red jasper and other pebbles.
7. The occasional bands of white, grey, and red crystalline limestone.
8. The presence in both of greenstone-dykes.
9. The absence of organic remains in both.

The quartzite of the country south of Lake Superior, unlike that of Lake Huron, contains vast beds of magnetic iron-ore.

Besides the Huronian beds, as already treated of, Sir W. E. Logan has described with great care a new formation, which he calls "the copper-bearing rocks." They are of great interest, and their more prominent characters may be best seen in columns 10, 11, 12 of the Synoptical Table III. They repose on the Huronian, unconformably to the crystalline rock below and to the Potsdam Sandstone above. This subformation occupies about 250 miles of the north shore of Lake Superior—that is, from Michipicoton to Pigeon River. It is very naturally divided into a lower and an upper group; the lower group, consisting of bluish slates or shales, with sandstones and interstratified columnar trap, extends from Thunder Head to Pigeon

* *Op. cit.* p. 14. † *Op. cit.* p. 14.

River, a distance of 42 miles. The upper group consists of sandstones, limestones, indurated marls, and conglomerates, interstratified with columnar trap.

b. *Norway.*—Leaving without remark the deposits in Arkansas and Missouri mentioned in column 12, because, although probably Huronian, they require further study*, I now proceed to Europe, where, at present, it is more than probable that the Huronian formation exists in Norway† in great quantity, and very clearly shown, as well as in other parts of that quarter of the globe.

In Norway, to a consideration of which country I shall first apply myself, it has received from M. Durocher‡ the name of "*the semi-crystalline schists,*" or "*the second group of Azoic formations,*" the lowest or first being Fundamental or Laurentian Gneiss§.

M. Durocher has called the first-named formation semi-crystalline because in Norway, as in Canada, it consists of two associated portions, the amorphous (sedimentary) and the crystalline (metamorphic); but it is a name very easily misunderstood.

M. Durocher professes himself unable to fix upon the age of these rocks with precision, but believes them to form a transition between the Fundamental Gneiss and the fossiliferous palæozoic rocks (Mémoire, p. 61), and that it corresponds in part to the Cambrian of Sedgwick.

This set of rocks does not, as in Canada, spread out in one mass continuously to great distances, but is in distinct tracts and basins within and upon the Fundamental Gneiss, which is the general base of all the rocks of the north of Europe.

There are six of these basins according to M. Durocher: viz. (1) at Nummendal and Haut-Tellemark; (2) in Central Scandinavia; (3) on the South-west coast of Norway; (4) on the sea-coast between Drontheim and Sogne Fiord; (5) in Finmark; and (6) near Tornea, at the head of the Gulf of Bothnia.

There is no difficulty as to the relations of this Huronian, if we may so call it, to the Fundamental Gneiss. It is seen to rest on it conformably in many places‖; on the gneiss of Schneehatten, in the Dovrefield; on the south side of the Sogne Fiord; in the Fiord of Urland, &c. And it is often unconformable, as in the valley of the Beine and Elv¶, in the Fillefield, and other places; but these

* Engelmann, Foster and Whitney's Geological Survey of Lake Superior Land District, p. 31.

† To Thomas Macfarlane, Esq., of Acton, Eastern Townships, L. C., belongs the credit of associating the Huronian of Canada with the semi-crystalline schists of Norway, in a most valuable memoir published, in February 1862, in the 'Canadian Naturalist.' I have laboured independently to the same end, upon materials gathered from other sources.

‡ The author of a survey of Norway, most elaborate as far as is within the power of an individual. His paper in the sixth volume of the 'Mémoires de la Société Géologique de France' is a model of geological description.

§ Von Buch, Sir R. I. Murchison, Keilhau, Kjerulf, Naumann, and Macfarlane have also done good work in this country.

‖ Mémoires de la Soc. Géol. de France, sér. 2, vol. vi. pp. 61, 90.

¶ *Op. cit.* p. 92.

M. Durocher considers local phenomena. But, as we learn from this author, the contact of this formation with Silurian is only seen with perfect distinctness on Lake Miosen *, where the latter is *transgressive* in a moderate degree, because, in the course of its undulations, the Huronian at that spot has not a high dip. The meeting of the Silurian beds of Hedemark, on the south of Lösness, with the Huronian or semi-crystalline Azoic rocks is rendered not so clear on account of the undulations of the latter, which have only a moderate dip, and are but feebly crystalline. Nevertheless it is here that it truly takes place. As in Canada, no very clear order of succession has been made out in the individual beds of the Norwegian formation. How could there be, when in both countries plutonic action has been intense, prolonged, and minute in its effects?

While these deposits present in their composition notable variations, from place to place, they nevertheless possess in every part of Norway the following common characters.

This second Azoic, or Huronian, formation is for the most part essentially a schist, argillaceous, chloritic, and micaceous by turns; changing often also from the foliate and crystalline condition to the amorphous or sedimentary, and this either suddenly or insensibly.

These schists frequently become siliceous, and then they may be accompanied by granular, compact, and subcompact quartzites; the latter being translucent, and with a conchoidal fracture. The Goustafield quartzite † is remarkably like that of Lake Huron. It is in mountain-masses, as in Canada, where it forms hills, whose sides shine bright and white from amid the dark pines. It is translucent, glassy, and clear; grey, greenish or bluish grey; and brittle, granular, or compact. It is also schistose; a tendency to which structure is increased by interspersed laminæ of talc, chlorite, or mica. Certain varieties on the east side of Altenfiord and elsewhere are red, green, violet, and white. Others assume the form of ribboned jasper (near Hjardal Church) or of hornstone, and become conglomerates and breccias, with a dark-coloured paste, and containing boulders of red and white jasper (on the Mandæla River), of quartz, chlorite-slate, and hornblende. Porphyritic intrusions are common among the quartzites, and those of Nummendal and Tellemark yield much sulphuret of copper, specular iron, and magnetite.

Besides these schists and quartzites, we have, in Norway, grauwackes (grits and conglomerates, in fact), conformable to the schists, &c., with a dark-green base, and pebbles of gneiss, granite, quartz, and porphyry; being the nearest approach, as far as I am aware, to the peculiar greenstone-conglomerate of this age in Canada. We must not always expect identities.

The Huronian limestone here is not quite equal in quantity to that in Canada, with the exception of that in Finmark ‡, where it is pretty well developed. It is not white, but dark grey or blackish,

* Mémoires de la Soc. Géol. de France, sér. 2, vol. vi. p. 62.
† *Op. cit.* p. 63. ‡ *Op. cit.* p. 98.

and both granular and compact. For details the Society is referred to the admirable descriptions of Durocher; for general information, necessarily limited, the column in the Synoptical Table III., under the head "Norway," may be consulted.

My reasons for believing the Norwegian *Second Azoic Group* to be *Huronian* are as follows; and it is believed that they are not without great force:—

1. Its place—lying on the Fundamental Gneiss, and covered by Silurian.
2. The discordance of the palæozoic rocks above in regard to it.
3. Its resolving, as in Canada, into several distinct and important parts, not altogether dissimilar to those of Canada.
4. The schistose rocks, the same in kind and proportion in both countries.
5. The immense prevalence in this formation of diorite or greenstone, and of hornstone, both in Norway and Canada.
6. The peculiar, greenish-grey, talcose quartzite, and quartzite-conglomerates, with aphanite and red jasper pebbles, in these countries.
7. The dark-coloured slaty conglomerates, with boulders of gneiss, granite, and greenstone, in both.
8. The limestones in the two regions, similar in kind, and much so in quantity, but few in comparison with the other members, though large in comparison with the Cambrian limestones. Here they are dark, perhaps from graphite.
9. The total absence of life in both regions.
10. The presence in both countries of certain ores of copper and iron. I shall content myself, for the sake of brevity, with referring to Table III. for information regarding the probable Huronian of France.

IV. *Relations of the Cambrian and the Huronian.*—Having now sketched the leading features of the Huronian series, while those of the Cambrian have been treated of in Part I. of this paper, I am at length enabled to exhibit such of their geological differences as point to a difference of epoch, and they are as follows:—

1. The Huronian is unconformable to the Silurian both in America and Europe:—not so the Cambrian.
2. The Huronian in Norway is conformable to the Fundamental Gneiss formation; and confidently believed to be so in America:—not so the Cambrian.
3. Its mass is principally conglomeratic, such conglomerate being of a special and typical kind:—not so the Cambrian.
4. It contains large and prolonged beds of marble:—not so the Cambrian, which is nearly destitute of limestone.
5. Its plutonic invasions and disturbances are quite different in quantity and intensity from those of the Cambrian period, being of five distinct epochs *.
6. The Huronian is more highly metamorphosed than the Cambrian (containing gneiss, &c., Foster and Whitney); notwithstanding that in Anglesea the latter formation has been completely changed into gneiss.

* A. Murray, Canada Geol. Report for 1849, p. 14.

7. It contains large deposits of copper, native and in a state of combination:—not so the Cambrian*.

8. The Upper Huronian of Logan (his copper-bearing rock) has no resemblance to, or affinity with, the Cambrian (see Synopses, Tables I. and III.).

9. It is destitute of the traces of life:—not quite so the Cambrian.

V. *Conclusion.*—It is now time to conclude by observing that the 1st, 2nd, 4th, and 9th of these points appear to be fatal to any idea of the Huronian and Cambrian being the same formation, while the rest are not without weight.

Three circumstances create in my mind a strong feeling that the Huronian is *greatly* the older deposit. These are:—

1. Its marked similarity, lithologically, to the Fundamental Gneiss formation.

2. The conformity of these two sets of beds.

3. The great interval of time which must have elapsed between the periods of laying down the Fundamental formation and the Silurian, if we are to judge from the occasionally vast thickness of the Cambrian.

Beyond all comparison, the Huronian is more wide-spread and extensive, as well as more uniform in its mineral constitution, than the Cambrian group. It is, perhaps, also more important economically.

[To face page 52.]

Trap, in conformable bands, on several horizons.

This series of beds is unconform- ... in the next

A Winchell

GEOLOGY AND MINERALS.

A REPORT OF EXPLORATIONS

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GENERAL GEOLOGY.

Without a map and extended profiles, it is very difficult to convey an idea of the geological structure of a country. That of the Lake Superior region especially requires illustration. In many places the regularity of the formations is broken up by disturbances, which require great detail of description. There are so many uplifts, dislocations, dykes, and protrusions, that generations may pass away, before the whole subject will be fully understood. I shall first refer generally to the west end of Lake Superior. It wil lassist very much in the understanding of what I have to say, if the reader will procure a map, embracing those parts of Minnesota, Wisconsin and Michigan which include the tributaries of Lake Superior. The principal sedimentary rocks are sand stone. The red sand stone of Lake Superior, is the lowest stratum in the United States containing fossils, and is therefore, the oldest sedimentary rock. It is known in New York as the "Potsdam Sandstone." It extends across the easterly end of Lake Ontario, through Canada to Lake Huron, at the Georgian Bay. Passing westerly beneath the north part of the bay and the lake, it appears on the St. Mary's river, where it causes the falls at Fort Brady.

From thence, it stretches along the south shore of Lake Superior, constituting the Pictured rocks. Here the dip is southerly, passing beneath the sedimentary formations, of the upper and lower peninsulas of Michigan. It is seen resting upon the igneous and metamorphic rocks in Wisconsin, crossing the Menominee, Oconto, Wolf, Wisconsin, Black, and Chippeway Rivers, everywhere dipping southerly, beneath the other members of the Lower Silurian system. Following the southern shore of Lake Superior from Grand Island and the Pictured rocks : it is seen most of the way to the west end of the lake, at the mouth of the St. Louis river. It extends up the river to the chutes, above Fon-Du-Lac, and thence southerly to the waters of the St. Croix river, uniting with the sand stone beds, of the Chippeway river. Passing beneath the Mississippi it reappears

in the valley of the St. Peters, beneath the magnesian lime stone, still dipping south into Iowa. This vast exposure is only a part of the formation as developed in the United States. In some places it is compact and vitreous quartz, with ripple marks. In others it is a gray and white crystalline rock, in beds and layers; being nearly pure, and colorless silex. In New York it produces excellent red and grey flags, very true and durable, which are shipped to the western cities. At the Sault St. Mary's it lies in thin but soft; mottled layers, red and grey, often shaly, which fall to pieces on exposure to frost. The Pictured Rocks and Grand Island exhibit many shades of color. Here it is thick bedded, and quite uniform in textnre; falling down from the cliffs into the water in immense blocks. Around the Huron Mountains and Kewenaw Bay, there are red, grey, and mottled layers, generally soft, which led several foreign geologists to form hasty conclusions; and affirm that it belongs to the New Red Sand Stone a formation newer than the coal. On the Canada shore, above Gros Cap, it has the same appearance, and also on the north side of Kewenaw Bay. Passing around Kewenaw Point there are beds of conglomerate, interstrafied with the Potsdam Sand Rock, which rest upon trap uplifts. Here the dip is northerly away from the intrusive rocks, pitching at a high angle beneath the waters of the lake. Isle Parisien and Caribou Island are sandstone. It folds around the northern base of the Porcupine mountains, where it embraces not only beds of conglomerate, but a stratum of black slate, 500 to 700 feet thick. The Apostle Islands and the shores opposite, are composed of red and mottled sand rock, of the same age, dipping gently to the south-east. It extends beneath the lake, coming out on the north shore, at Isle Royal, interstratified with trap-rocks. Around the western portion of the lake, the dip is southerly, at various angles, interrupted; and sometimes reversed, by the upheavel of trap-ranges. The Bad River and Montreal trap-uplift, which is merely an extension of that in Point Kewesaw, tilts up the whole Potsdam formation to the north, nearly on edge. The Montreal river which forms part of the boundary between Michigan and Wisconsin, runs over the upturned edges between 9,000 and 10,000 feet, which however, is not the full thickness of the formation, at this place. A trap-uplift which crosses the Black Aminicon and Brule rivers in Douglass county, Wisconsin, has risen up through, without materially disturbing the general stratification. On the north shore, and in the valley of the St. Louis river, the dip is irregular and rapid, ranging from 5° to 18°; but on the south side of the lake, at, and west of the Apostle Islands, it is very slight and regular. On the waters of the St. Croix, its inclination is still south-westerly, somewhat broken by trap-outbursts, near the mouth of Snake and Kettle Rivers, and at the falls of St. Croix. These low trap-uplifts are the dying out in

New Ulm Minn,

that direction, of the great Kewenaw Range. At the summit of the country between Lake Superior and the waters running southerly, is a large tract of igneous and metamorphic rocks, entirely surrounded by the Potsdam. It has the same characteristic fossils on the St. Croix, as in the State of New York, but over large intermediate spaces, no fossils are yet known. Without any such evidences of identity, at remote points, the formation can be recognized by means of its stratigraphical relations. It is seen to pass beneath the higher beds of fossiliferous rocks, wherever they exist, along a line of one thousand miles.

The Lake Superior trap-rocks carrying native copper, are of the same epoch as the Potsdam. Those which carry the sulphurets of copper belong to a different and older system, which in Canada is called the "Huronian."

Throughout the native copper system, there are alternating bands of trap and sandstone or conglomerate, proving them to have been contemporaneous. Whether the amygdaloid copper-bearing trap is of igneous origin, is a subject which is yet to be discussed. The trap beds, which carry valuable copper-bearing veins, belong to the red sandstone system. The interpolated layers of slate sandstone and conglomerate, as well as the trap beds, carry native copper. It is not in veins alone that copper is wrought, but there are beds, which offer in several places, valuable mining ground.

The metal exists in true *veins*, and also in *layers*, at the contact of strata, and sometimes as a component part of the beds.

On the north-west shore of Lake Superior, from Du Luth, at the mouth of the St. Louis, to Grand Portage bay, a distance of 160 miles, the same system exists, as upon the south shore, but with a reverse dip. It extends across to and through Isle Royale, and thence to the island of Michipocoten, the strata dipping southerly, beneath the lake. The upheaval on the north shore, is in a somewhat curved form, while that on Point Kewenaw is nearly straight, being on opposite sides of a trough or elongated basin, the bottom of which is occupied by the lake. We can therefore study the Minnesota mineral range, by comparing it with that of Michigan and Wisconsin, the whole forming one geological system.

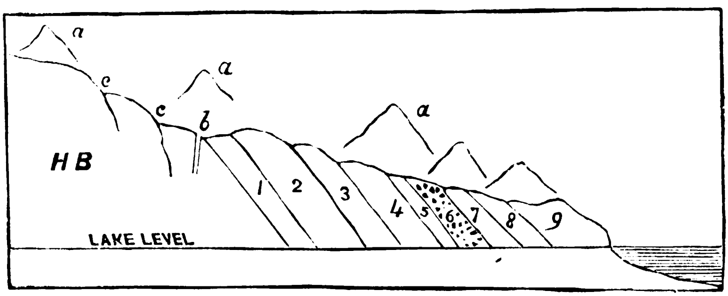
A line curved a little to the north from the great falls of St. Louis river to the middle of the west end of Isle Royale, represents very nearly the out-crop of the red sandstone on the north. This general line is a short distance from the shore in the lake. The beds of sandstone which are seen on the north shore, near the mouths of some of the rivers, and which are interposed between beds of trap, belong rather to the trap, than the sandstone system.

There is, on both shores, a belt, where these rocks alternate; the upper part of the belt being more sandstone than trap, while in the lower part, trap beds predominate. Copper veins are found in the trap beds, but they are not productive when they pass into the sand rock. If, therefore, the direction of the veins is across the strata, their producing part is short. If they run parallel to the strike of the strata, and especially if they dip conformably, such veins are worthy of attention. The distinction between *veins*, and mineral-bearing *beds*, should always be borne in mind in forming a judgment upon mineral deposits.

The trap belt which lies beneath the sandstone, occupies a space along the north shore from Portland to Grand Portage Bay. As these strata also dip south-easterly beneath the lake, they rise successively to the surface as we go north-westerly towards the interior. The trap formation has an irregular width of 5 to 15 miles from the shore, being narrowest at Portland and widest near Two Island river. It is not only very much disturbed, dislocated and contorted by dykes and by igneous outbursts of greenstone and quartz, but it was originally not uniform in structure. This will appear, by examining attentively, the local cross sections, which will be given hereafter. A good general idea may be had, however from the profile introduced here, taken on the waters of the Manidowish river, extending from its mouth back to the hornblende rocks in the rear. It is in T. 58, N. R. 6 W. As it was taken before the surveys were made, the distances are merely estimates:

Profile of the Rocks on the Manidowish River. Course North-West, Distance 8 or 10 Miles.

(NO. 1.)



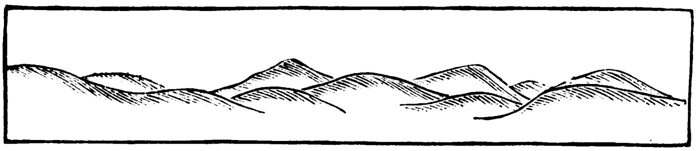
a. a. a., Peaks of Quartzite and Greenstone, 300 to 900 feet above Lake.
H. B., Hornblende Rocks resting upon Sienite and Granite.
c. c., Falls of the Manidowish.
b., Trap Dyke.
1—Bed of Red trap 200 feet thick.
2— " H. Blende rocks, 1,000 feet thick.
3— " Red trap, 200 feet thick.
4— " Coarse, variegated, altered Sandstone, 100 feet thick.
5— " Red, flinty, thin bedded trap, 25 " "
6— " Coarse, red, trap Breccia, 50 " "
7— " Altered, shaly Sandstone, 20 " "
8— " " Sandstone thickness not seen.
9— " Amygdaloid trap, red, breccia and altered Sand Stone, in alternate beds extending into the Lake at least, 2,000 feet thick.
Dip not regular, varying from 5 to 15 deg. South-East.

The dykes cut through all the strata, sandstone, trap and hornblende. It is the same with the irregular outbursts of greenstone and quartz, which have a much greater metamorphic action upon the adjacent rocks than the dykes; because the intrusive mass is greater. These effects will appear distinctly in the local profiles.

Behind the trap ranges lie the hornblende rocks, which are but imperfectly stratified, but which are frequently slaty, as at the St. Louis river. This formation is of great thickness. The sandstone and conglomerate beds on the St. Louis river, rest on the hornblende slates, without any intervening trap. Farther east, the trap has pushed the sandstone formation upward, and occupied its place, or becomes intercalated with the sandstone strata. The northern outline of the trap formation also represents the southern edge of the hornblende rocks. They occupy a belt, the width of which is not yet determined, which, in its general course is parallel to the shore, extending from the St. Louis to the mouth of Pigeon river.

There is very little doubt but the valley of the Cloquet river, rests on these rocks. Reasoning from what is at present known, its breadth is greater than that of the trap belt, which lies between it and the shore. From the top of the trap mountains, a view can frequently be obtained, ranging twenty to thirty miles. As the different formations have different topographical outlines, something of an opinion can be formed of the geology of distant points, by these extended prospects. The hornblende ranges are less abrupt, and less jagged in their outlines than the trap, but more irregular than the granite and seinite.

(NO. 2.)



Outline view from Carlton's Peak, distant 15 or 20 Miles to the North-West,

Behind the hornblende system is the imperfectly defined region of the granite, sienite mica slate siliceous, and talcose rocks, extending to and across the national boundary. The Mesabi Range, occupies the watershed between the waters of Lake Superior, and those of Hudson's bay. In many cases, the sienite and granite appears to be more recent, than the metamorphic slates, having all the appearance of intrusive rocks. This range is neither bold, or elevated. The country on and adjacent to the summit, is well characterized by Nicollet, as a "region of rocks and water."

A. Winchell

GEOLOGY AND MINERALS.

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From the sources of the Mississippi, easterly to the heads of the Vermillion, and thence to the lakes at the source of the Pigeon rfver, the crest line is nearly level, and elevated only 1600 to 1800 feet above the ocean.

A large part of the summit region is covered by water, in swamps and lakes, with either sandy ridges or bare rocks between. In places, the coarse boulder drift is piled up in hillocks, or encircles the rocky summits. In well defined valleys, the drift clays are deposited. They are dun, purple and red in color, and are laminated. The coarse gravel and boulder portions, overlie the fine parts, and pass into them by alternating layers.

This formation of superficial materials, the result of the last geological change, is due to a period of universal ice, when this country, as low as latitude 41 deg., was in the condition, that Greenland is now. Wherever the rocks are visible on this water-shed, they are smoothed, polished and grooved, by the movement southward, of the glaciers of that era. To show the general direction of this movement, I give the bearing of these glacial etchings, on and near Lake Superior.

At the Pokegema Falls on the Mississippi, in latitude about 47° 15 min. north, I saw what I consider to be an outcrop of the Potsdam sandstone. Below Pokegema no rock exposure was seen in place on the river, until after passing Fort Gaines.

On the shores of Cass Lake, Lake Winnebigoshish, Sandy Lake, and Mille Lac, nothing is visible but transported boulders and boulder drift.

Those rocks on Vermillion river and lake, which should carry the precious metals, are concealed from view along the dividing ridge, at the heads of the Mississippi. Nothing but low drift ridges and knobs are seen there. The elevations between the waters of Turtle river, which Beltrami considered as the true source of the Mississippi, and the waters of Red river, are slight drift ridges, so low that the waters might easily be turned northward across the summit. As low down as Lake Winnebigoshish, by the aid of a dam of moderate hight, and a cut less deep than has often been made for canals, the Mississippi might be directed into the great fork of Rainy Lake River.

Near Breckenridge, on the Red River, Dr. Owen discovered a low outcrop of Silurian lime rock. These are the only known exposures of sedimentary rocks over a large space, along the summit, around the head waters of the Mississippi. In the drift materials however, there are numerous fragments of Silurian lime rock; and explorers to the north of Lake Superior, in Canada, report that there is an extensive field of fossiliferous strata in that direction. It is probable, therefore, that the geo-

logical rim of the basin of the lakes, and the Lower Mississippi, where the azoic rocks would appear, if it were not for heavy deposits of drift, lies nearly in the extension south-westerly of the Mesabi Range, crossing the river near Crow Wing, and thence to the St. Peters, above the Waraju river. From this axis as an anticlinal, the sedimentary beds dip away on the north and south towards their respective basins, which are each of immense extent. On the Elk river, north-east of St. Cloud, it is reported that this band of igneous and metamorphic rocks, rises above the soil, and that pieces of copper, have been found in place. Copper nuggets are common in the drift materials in several states to the south, and southwest of the copper regions of Lake Superior. In Michigan, Wisconsin, and even in Ohio, pieces of native copper are found, which were transported by the drift forces, in company with boulders of northern rocks. The finding of such specimens is no certain evidence of a copper mine in the vicinity. But if it is true that trap rocks are exposed on Elk River, in connection with mica slate, granite, or sienite, they should be examined for copper veins. As I have seen these rocks only in the streams, where the drift materials have cut down to the solid strata, there was very little opportunity to judge of the existence of veins. It is singular that they should occupy so extensive a tract, from the Embarras river to the St. Peters, a distance of 250 miles, with a breadth of from 40 to 60 miles, and present no decided mountain elevations. On Rum river, below Mille Lac, they are barely visible, causing ripples and low chutes, only slightly covered with earth, nowhere rising in cliffs above the water level.

The Mississippi has uncovered them more thoroughly, from Little Rock to and below the Sauk Rapids. From thence, westerly along the line of uplift to the St. Peters, above the mouth of the Waraju, the drift covering envelopes them, so that explorations are impracticable. Where they re-appear from beneath the prairie, in the channel of the Upper St. Peters, there are very few projections above drainage level.

The Vermillion lake system is represented in detail by a reconnoisance made across the strike of the formation, the results of which will be given, in the nature of a profile of the rocks, in a north and south direction. It will be seen that the rocks are gneiss, mica slate, quartz, sienite, and granite, The azoic rocks, both crystalline and slaty, are often called metamorphic, on the theory that they once existed as a sediment; afterwards changed by some unknown agent, to crystalline schists, or slates.

However that may be, where rocky formations of the character I saw on the waters of Vermillion river and lake, carry veins of ferruginous quartz, especially where there is iron and copper pyrites with the quartz

there is more or less gold. Where there is the sulphuret of lead (Galena) there must be some silver. The proportions of the precious metals are variable; but veins in such formations, carrying the sulphurets of iron, copper and lead, invariably yield gold and silver. The same formations extend westerly across the Great Fork of Rainy Lake River, and northwesterly to, and including the Lake of the Woods. As far as they have been explored in that direction, there is the same lack of high mountain ranges,that characterizes the extension of the same formation to the southwest, in the direction of Rum River, and thence to the St. Peters. On the Grand Fork, the metamorphic series appear in low falls, chutes, and rapids, but do not rise into cliffs and mountain elevations. Around Vermillion Lake, although the rocks are not much elevated above the surface of the water courses, the earthy covering is very slight. The drift forces left the strata comparatively clean.

In most of the bays and inlets, and on most of the islands and headlands, the rocks are exposed to view as distinctly as though they rose in mountain bluffs and precipices. This renders it easy to make surface explorations. In regard to access, the nearest point on Lake Superior where there is a harbor, is called Beaver Bay. I estimate the distance from the south-east part of Vermillion Lake, by a practical route, to be fifty-five miles, and from Du Luth, about eighty miles.

As the siliceous hornblende formation of the north shore, in the rear of the trap, has the same geological position as that on the south, in Ashland county, Wisconsin, which embraces bands of magnetic iron ore, I was confidently expecting to meet with it in Minnesota.

I saw none, but have seen specimens said to have been fonnd within twelve miles of the mouth of the St. Louis River.

Recently, some thin layers of iron ore are reported within six miles of the lake shore.

I shall be disappointed if workable iron ore, does not exist within such a distance of the lake as to render it of practical value.

Mr. Eames has discovered both magnetic and specular ore a short distance east from Vermillion Lake.

PHENOMENA OF THE DRIFT PERIOD.

BEARING OF GLACIAL ETCHINGS

ON THE ROCKS OF THE WESTERN PORTION OF

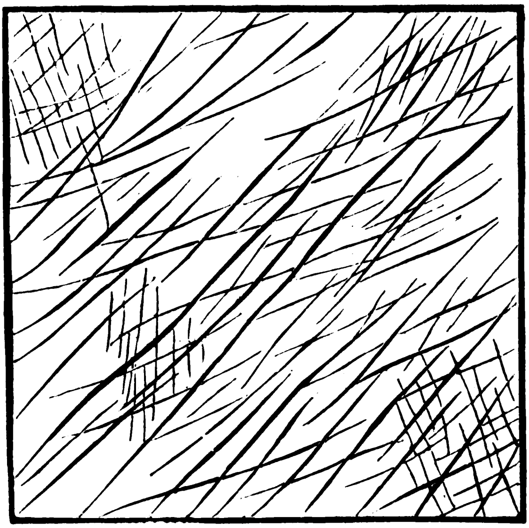
LAKE SUPERIOR.

LOCALITY.	BEARING OF THE LINES.	KIND OF ROCK.	REMARKS, AUTHORITIES, &C.
Vermillion Lake	South 5° East. (True)	Mica and hornblende slate.	C. Whittlesey—Rocks much worn and polished.
Sturgeon Lake,........................	" 55° West "	Hornblende slate.	" " " " " " "
Rainy Lake,............................	" 40 to 60° " "	Talcose slate and granite.	" " Rounded and polished domes.
Rainy Lake,............................	East and West,	" " " "	James Hector—Geologist to Capt. Palliser's Expedition
Lake of the Woods,....................	South 30° West.	Metamorphic slates.	" " Mean of four observations.
Dog Lake..............................	" 10° "	" " " "	" " " " six observations.
Lake of 1000 Isles,....................	" 5° East.	" " " "	" " " " " "
North shore of Lake Superior, Wissokate River,	" 25° West.	Trap.	Dr. Norwood, at Lake Level.
do. do. Passabika River,............	" 46° "	"	" " " " " very distinct.
do. do. Sucker River,..............	" 45° "	"	C. Whittlesey, " " " "
South shore of Isle Royal,............	" 20 to 25° "	"	E. Desor—Rocks worn into troughs and hollows.
Scovill's Point, do do	" 50° "	"	" " Extensive polished surfaces.
Ackley Bay, do do	" 75° "	"	" " Deep excavations and furrows.
Chippeway Harbor do	" 50° "	"	" " " " " " "
Dalles of Tyler's fork, Ashland Co., Wis.	South 45° East.	Magnetic iron ore.	C. Whittlesey—In a gorge of the mountains.
2 miles West of Tyler's fork, " "	" 40° "	Magnetic Iron ore and quartz	" " " " " "
Sec. 17, T. 44, N. R. 2 West, " "	" 55° West.	" " " " "	" " 1000 ft. above Lake Superior.
" 24 " " " " 4 " " "	" 45° "	" " " " "	" " " " "
" 20 " " " " 5 " " "	South.	Quartz.	" " Elevation 800 to 900 feet A. L. S.

PHENOMENA OF THE DRIFT.

These observations prove that the glacial movement was from the North-east. It was the same on Point Keweenaw, and in the Marquette Iron Regions, where the general course of the stria agrees with the above in showing a motion from North-east to South-west. On a map of the United States I have indicated by arrows, pointing Southerly, the direction of the glacial etchings along the entire valley of the Lake and the St. Lawrence. The parallelism of these arrows is remarkable. In places there are two or more sets of stria crossing each other at various angles, showing a movement temporarily in different directions.

No. 3.



Fac simile of a slab of limestone, polished and striated by the drift forces, showing two sets of prominent lines, and minor cross stria. Main lines North-east and South-west.

But the most conspicuous lines, grooves and troughs, and also the most numerous, are those pointing South-westerly. At the West end of Lake Superior, this coincides with the axis of the depression, forming the natural basin or bed of the Lake. In gorges and breaks of the mountain ranges, like those in the Penokie range of Wisconsin, and the Minnesota range of Michigan, the lines follow the course of the gorge, marking and polishing both the sides and the bottom. But on the summits of the mountains, and on broad, level spaces in the valleys, they have a singular uniformity in direction. These etchings pass everywhere beneath the surface of the Lakes, no doubt, to the lowest parts, and rise to the tops of the highest mountains; 1,000 to 1,200 feet above the surface. In New England they have been noticed at an elevation of 3,000 feet above the ocean, which is higher than any of the Lake Superior ranges of mountains.

There must have been a thickness of ice sufficient to fill up the basins of the Lakes, and cover the elevations around their shores, which rise 1,600 to 1,800 feet above sea level. This prodigious mass had a slow but resistless progress, South-westerly, over the country; which continued through a long period of time, grinding down the asperities of the rocks, and pushing forward the loose materials in the same direction.

It is not a long time since the origin of this motion was understood. Recent explorations in Greenland, by Dr. Rink, a Danish Naturalist, and Dr. Hayes, of the Kane Expedition, show that such a movement is now in progress over vast tracts, in that region of perpetual ice. The icy mass which invests the interior of the continent of Greenland, progresses from the center towards the coast, without reference to mountain slopes. It moves so slowly, towards the dissolving edges of the mass; at sea-level, as to require close observation to detect it. The central expansion being an irresistible force, there is no mode in which it can be relieved but in the movement, of the outer portions of the field. This takes place, not only down the mountain declivities of the interior, but across level spaces, and even up inclinations of the surface, in the direction of the sea. On the sea-margin the climate is milder, the mass to be moved is diminished by thawing, and by the same process it is made softer; so that it yields more easily to the accumulated pressure from the rear. The ice-bergs of the Atlantic are derived from this moving mass, as it is pushed into the sea. When these fragments break away, it occurs by means of their buoyancy in water, rising from the bottom, over which they are being forced; and floating away.

The thickness of the ice-front, from which they are broken off, is from one to two thousand feet. With these operations open to modern inspec-

tion, the idea of an ancient glacial envelope, covering the Northern Lakes to the tops of the mountains, ceases to be a mystery. Nothing is required to bring the ice-field of Greenland down to our latitude but a decrease of temperature. Changes of this kind are well attested in the Geological history of the Earth. During the coal-period a tropical climate pervaded a large portion of our globe. The cause of such wide-spread changes is not yet understood, but in any investigation immense duration of time must be an element.

During our ice-period, the Southern limit followed an irregular line through New Jersey, Northern Pennsylvania, Ohio, Indiana, Illinois, Wisconsin, and Iowa.

It was irregular, but oblique to the parallels of latitude, and nearly parallel to the Isothermal lines of the Mississippi Valley. This Southerly limit, is marked by the last of the boulders of Northern Rocks, and by the termination of the glacial etchings. In the Mississippi Valley, the lowest point is near Dayton, Ohio, not far from Cincinnati. The Southerly edge of the universal ice-field, was dissolved by an increased Southerly temperature, as that of Greenland is by the warmth of the sea. This line of equal temperature, not having been East and West, but North-westerly, led to a movement at right angles to it; that is, from North-east to South-West, modified by the topography of the country. There is no proof that the general surface of the land has changed since the drift-period. The general elevations and depressions were the same then as now. Where the rocky strata are soft and yielding, there has been a mechanical destruction of the summits, by the ice movement, and in many hollows the loose materials have been deposited.

But, if there has been a change of level, as it regards the sea, it must have been universal. No evidences of local disturbances have been found in the United States since the era of the drift. In Minnesota, the rocks, instead of being denuded by drift action, have been concealed by it, over such large tracts, that I have dwelt at some length upon the phenomena of the age of ice. The difficulty in defining the limits of the Iowa coal-field, on the North, in Minnesota, is owing to the great depth of the drift deposits. Borings and shafts are necessary to determine the value of these coal-beds along the Northern outcrop. One of the characteristics of regions where this action has been conspicuous, is the existence of Lakes. When we proceed Southerly, beyond its operations, they are seldom seen. The region around the sources of the Mississippi is an example of the profusion of Lakes, due to the closing out of the drift period. In Canada, in the New England States, and in Europe, most of the fresh water pools are due to the same cause. Scattered through the

mass of superficial materials, on the waters of the upper Lakes and the upper Mississippi, are trunks, branches and leaves of trees, not yet mineralized, and, in many cases, not yet rotten. They are of species now living in the North, generally cedar, pine, and spruce. Over all the Northwestern States, the waters which covered the country, at the close of the ice period, were evidently fresh.

[illegible] Water at St Paul (Whittlesey) 677
[illegible] water at St Paul (Hill) 676.

GENERAL ELEVATIONS IN MINNESOTA.

I have compiled a table of elevations, by different observers, most of them determined by barometer. This instrument as explorers are compelled to use it, having only a few readings at a place, subject to the weather, gives only approximate results. Dr. Norwood's profile of the country, from Lake Superior to the Mississippi, differs so much from Nicollet's, in the elevation of the river at St. Paul's, that I have called in the aid of the Lake Superior and Mississippi R. R. Co. Their Chief Engineer has kindly given the level of the river at low water, compared with Lake Superior, as determined by instrumental survey. The river is about 87 feet above the lake.

Nicollet was a very careful and patient observer, but his base was far distant, at the Gulf of Mexico. The elevation at St. Paul's, as determined by him, is 89 feet too much. The elevation of Lake Superior is subject to a plus or minus correction of two or three feet. Two instrumental levels to this lake, one from Huron along the St. Mary's river, and one from Bay d'Enoch, on Lake Michigan, give results which differ 10 feet.

As the great lakes have fluctuations of five to seven feet, surveys made at different times, are liable to a considerable error, especially when they are carried from one lake to another, and not direct to the ocean.

Bayfields' barometrical determination for Lake Superior in 1824 gives 627 feet as its elevation above tide. The survey of a railway from Bay d'Enoch, has it 610 feet, and the Canadian survey from Lake Huron about 600. For the present use I take the mean of the two last, or 605 feet. With this as a base, the river at St. Paul's (low water) is 692 feet above the ocean.

This correction of 89 feet, deducted from Nicollet's elevations of points on the river below, brings them more in harmony with the only railway level I have been able to obtain. Making that deduction, the hight of low water, at the mouth of the St. Croix should be 645 feet.

do	at Lake Pepin	630 "
do	at mouth of Black River,	594 "
do	at mouth of Wisconsin river,	518 "
do	at mouth of Fever river,	503 "

The last place is determined by a preliminary railroad survey from Racine, on Lake Michigan. Without this reduction, there would be more than 100 feet rise in the river from Galena to Prairie du Chien. Assuming that the elevation at St. Paul's and at Galena is well established, the total descent of the stream, in that distance, is 189 feet.

Those by Mr. Nicollet up the river and on the St. Peters, away from its mouth, I do not alter. They are undoubtedly as near the truth as barometrical levels can be had, by means of an instrument used on a journey. For general purposes they can be regarded as correct within 100 feet

TABLE OF ELEVATIONS.

LOCALITY.	Hight ab. Ocean, in feet.	OBSERVERS AND REMARKS.
Lake Superior	605	
St. Peters, low water in Miss. River,	692	Lake Sup. and Miss. R. R. Survey.
Miss. above Falls of St. Anthony	777	do do do
do mouth of Crow Wing	1130	Nicollet—Barometer.
do " Sandy Lake	1253	"
do Pokegama Falls	1340	"
do Cass Lake	1400	"
Leech Lake	1380	"
Itasca Lake	1532	" adjacent hills, 1680 ft. ab. sea.
Snake river, 75 miles from St. Paul's	1015	R. R. Survey.
Kettle river, at Fortuna	946	do do
Summit, 22½ miles from Lake Sup.	1183	do do
Summit, 18 miles S. of Superior city	1272	Survey of St. Croix R. R., Wis.
Trap range, 9 miles above the falls of St. Croix river	1076	Norwood—Barometer.
Pokegama Lake	974	do
Summit of Grand Portage	1066	do
Great Palisades, N. shore of Superior	1055	Bayfield.
McKay's Mount, " " "	1824	do
Carlton's Peak " " "	1542	Owen—Barometer.
Summit of Sandy Lake Portage	1400	Nicollet.
Mesabi Range, head St. Louis river.	1750	Estimate.
Rainy Lake	1080	do
Summit between Lake Winnebegoshish and Grand Fork	1423	Nicollet's elevation of lake as a basis, 1391 plus 32 eq. 1423.
Summit between Turtle Lake and Red River	1413	Est. from Cass lake, at 1402 by Nicollet; adj'ct hills 72 ft. higher.
Big Stone Lake	968	Nicollet.
Lac qui Parle	946	do
Devil's Lake	1476	do adjacent hills, 1766.
Head of Wild Rice river	1372	do
Forks of the Shayen-ojn and Beaver Lodge rivers	1328	do
Summit of the Coteau de Prairie	2046	do

In ascending the river above the falls of St. Anthony, I determined its width at several points to be as follows :

At mouth of Rum River,	627 feet.
" " " Crow Wing,	458 "
" Sandy Lake,	350 "
" Leech Lake Forks,	132 "

MISSISSIPPI RIVER.

Here the Mississippi properly commences to be a river worthy of one name to its mouth. It here assumes that sluggish and tortuous course which it holds to the Crow Wing river. The banks and the adjacent country are low and generally swampy. With the exception of the falls at Pokegama, no rocks appear in the river. At Pokegama there is a vertical descent of 10½ feet through a gorge eighty feet wide, and a rapid, extending forty rods below, over what I conceive to be altered Potsdam sand-stone. The ripples of the river are few, and are occasioned by collections of boulders, from the drift. Bluffs and points of coarse Northern drift, rise sometimes as high as eighty and ninety feet above water level. From none of these bluffs could I discern mountain ranges, but only a vast extent of flat lands, lakes and swamps, with low ridges of pine.

FLUCTUATIONS IN THE LEVEL OF THE LAKES.

The rise and fall which has long been observed upon the surface of all the Northern lakes is a matter of practical consequence, in regard to harbors, channels and docks. From 1845 to 1854, I made occasional measurements of the state of the water in Lake Superior referred to a mark on the rocks in Copper Harbor. I was assisted by Prof. Mather, D. D. Brockway, and Mr. Turrill. Since 1854 the Superintendent of the Sault Canal has kept a daily register, and since 1860 the United States, in connection with the survey of the Lakes, have had two stations where daily observations are made. The lowest known stage of water occurred in 1828, as reported by Capt. Dearborn, U. S. A. In 1838, according to Major Lochlan, of the British service, it was 3 feet higher than in 1828. It was very high in 1845. The highest water during the twelve following years occurred in September 1856, when it was 3 4-10 feet above the average of March, 1847. There is in this, as in all the other lakes, an *annual* ebb and flow. Low water within the year, or the low stage of the annual fluctuation, occurs in March, and high water in September. According to the results of two years' measurements, this difference is 2 feet. What the extreme range is during a long period, cannot be determined without observations extending through at least fifty years. These changes of level are due to variations of the seasons within the year, and during successive years. This Lake is the only one which has conditions strictly its own, for all the lakes below are affected by water discharged into them from those above. The questions of fall of rain, evaporation and temperature ; all of which go to make up

climate; require examination throughout the entire Lake country, before their joint effect can be calculated.

On Lake Erie, since the occupation of white men, a change of level has been observed amounting to 7 feet; on Lake Michigan of 6 feet. If a series of seasons occur which are more cold and wet than the average, a rise must take place, above the mean level. When the meteorological condition of the Lake country is the reverse of this, there will be a corresponding depression. The mean level of all of these lakes is yet to be determined, by the registers that are now being kept. At the same time the fall of rain is being gauged, the temperature noted, and the moisture of the atmosphere determined. In due time these observations will remove all the mystery with which these fluctuations have been invested, by demonstrating that they are due to meteorological changes in the seasons. George R. Stuntz, Esq., of Superior, a close observer of what occurs in the natural world, is of opinion that there has been a permanent settling away of the land at the west end of Lake Superior. On all the lakes there is evidence of a permanent lowering of the surface of the water beyond the general fluctuations I have referred to. Beaches of water-washed pebbles, precisely like those now forming, are seen at an elevation of 18 to 20 feet. This is what would necessarily follow from the gradual wearing down of their outlets. The process is so slow, however, that it is not perceptible during the life of one generation or individual.

CLIMATE.

Observations upon temperature which have been kept at Superior, at the West end of Lake Superior, for more than ten years, show that the climate around this part of the lake is much milder than it is further East. The snow is less deep, and the climate better adapted to agriculture. This is in accordance with a well established principle of meteorology, that proceeding Westward on lines of latitude, the climate becomes milder. I have seen Indian corn growing at Red Lake in latitude 48° North, which produced 30 bushels to the acre. Further West in Minnesota, and North in the Valley of the Red river, in Canada, and in the Valley of the Saskatchewan, is a tract large enough for several states, where wheat flourishes as a certain and abundant crop. Those who consider this region to be a barren waste, make a gross mistake. Minnesota, Dacotah, and the country to the North of it, including the Valley of Lake Winnepeg, constitute an important country, destined to be the main resource of North America for wheat.

BARAGAS RIVER.

A short distance East of Two Island river, is a stream called by Dr. Norwood the "Inaonani." At the mouth of this creek there was in 1848 a rough, weather-beaten cross nailed to the tall stump of a tree, on which was written in pencil the following words: "In commemoration of the "goodness of Almighty God in granting to the Reverend F. R. Baraga, "Missionary, a safe traverse from La Pointe to this shore, August, 1843." This passage across the open lake from the Apostle Islands is seldom made, on account of the risk it incurs. The distance from the outer island is about 30 miles. Following the coast by way of Lake Superior, it is 175 miles. Our voyageurs stated that while Father Baraga was on the traverse, in his birch canoe, a gale arose, and as there are no harbors at this part of the coast, he was driven upon the rocks at the mouth of this creek. I have endeavored to perpetuate this incident, and the memory of Father Baraga, by naming the stream after him. Between Baraga's river and the Kawimbash, which is next to it on the East, the strata begin to emerge from the Interior and strike into the Lake. From hence to Pigeon river they are represented by Dr. Owen and his assistants as more disturbed than they are to the South-West. There are bolder uplifts, heavier dykes, which are more columnar; and more compact trap, with less of the softer and amygdaloidal variety. In rear of the trap, the hornblende series approaches nearer to the lake, coming to the shore below the Grand Portage, on the point between it and Pigeon river. The dykes extend into the hornblende system, and also heavy veins of calc spar. These rocks are not so favorable to native copper, as those to the South-West; but the veins here have produced silver and may contain the ores of copper. I have not examined the country below the Kawimbash.

In the Two Island river region, the trap beds resemble those of the French and Knife river district, and are worthy of close inspection for mineral deposits. The most extensive outbursts are here as they are elsewhere on this coast, composed of what is called "greenstone," or crystaline trap. There can be but little doubt that it is of igneous origin. It frequently takes the form of a stratum; as though it was forced out between the beds of stratified rock, but more often the crystaline uplifts are in irregular masses, somewhat dome-like; associated with quartz and columnar trap. They disturb the general system more than do the dykes; and the viens are pinched out on entering the greenstone, or carry iron pyrites. The relations of these intrusive masses are shown in several local sections.

KAWIMBASH RIVER—CARLTON'S PEAK.

From the mouth of this stream, a little out from shore, a remarkable peak is visible; situated about due North, in the interior. It is discernable in clear weather from the Apostle Islands, on account of its isolation.

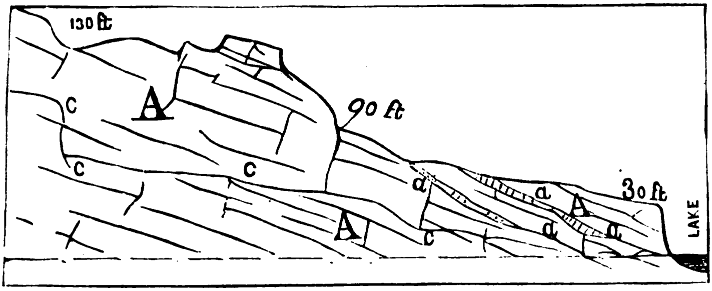
The rocks on the coast dip towards the lake at an angle of eight to ten degrees. Striking inland for the peak, at about a mile we crossed a belt of quartz rock, with a bearing nearly East and West. Between the uplifts are an abundance of large, fine white cedar trees. At two miles there is a bold greenstone uplift facing South; its course ranging with the quartz, and its elevation about three hundred feet above the lake. The summit of Carlton's Peak is a smooth polished crown of gray quartz, of 900 feet elevation, and about three miles from the shore. It is detached on all sides from the adjacent ranges, and is difficult to ascend. No higher land exists in the neighborhood. In the West and South-West are confused peaks of trap, presenting a jagged outline on the horizon. On the North are the more curved and rounded summits of the granite, and metamorphic rocks already noticed. Turning towards the lake, the Apostle Islands, the Bad River, and even the Porcupine Mountains, were distinctly visible. Passing from the Peak westward, I examined the Kawimbash river, which is referred to in detail by Dr. Norwood, in Owens' Report. Crossing the country to the West, we came to Baraga's river, about four miles from the lake. There are between the two streams prominent knobs of greenstone, rising two hundred and fifty and three hundred feet above the lateral valleys, and six hundred to eight hundred, above the lake. Near the mouth, the trap rocks are principally of the softer, coarser grained amygdaloidal cast, favorable for copper, though I saw no veins. As the crystaline trap is much harder and tougher than the amorphous and earthy varieties, it rises more prominently above the surface. Neither the drift forces, nor the disintegrating power of the atmosphere, reduce hard compact rocks as fast as they do softer ones. About two miles from the lake are heavy beds of red and brown flinty trap, dipping South-East eight degrees; covered by drift materials two hundred feet thick. The stream is rapid, but the rocks are not always exposed in its bed. Large boulders of quartz, greenstone and red quartzose trap lie in and along the stream, derived from the heavy drift beds on its banks. The part of this stream which I examined was estimated to be five miles, and its fall in that distance 400 feet.

TWO ISLAND RIVER.

On this and on Two Island river, which is next to it on the West, the rocks are similar, and promise well for metal-bearing veins. At the mouth of Baragas river, the beds are represented in the annexed profile.

(NO. 4.)

Profile up the gorge of the Inaonani or Baragas River, looking East. Course, North-West, 40 rods.



A, A, A, Brown amygdaloid trap, heavy bedded; dip South-East 10 deg.
a, a, a, Layers of soft red trap.
c, c, c, Thread of stream at the bottom of the gorge.

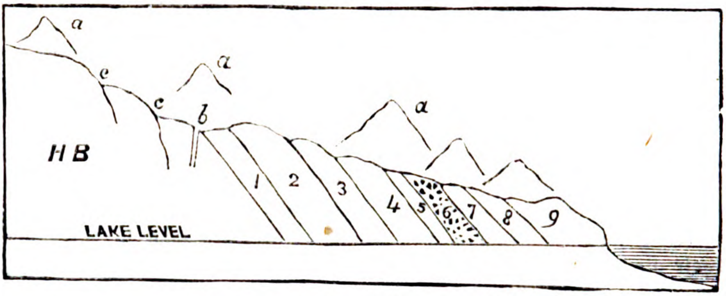
Coasting Westerly from Two Island river the rocky strata seen on that little stream, and particularly described by Dr. Norwood, came out on the shore, in the same order of succession, as they are seen in the creek. Their dip is quite regular to the South-East by East, about 18°. The comparative regularity of the beds in the district drained by the Kawimbash, Baraga, Two Island and Manidowish, is one of the encouraging signs of their mineral value. After passing a little nook in the coast, where there is a boat harbor, the first stream to the South-West we named Conglomerate creek. Along the first quarter of a mile up this water-course, it pitches rapidly over a heavy bed of good amygdaloid trap. I estimate the fall in that distance at 150 feet. The dip is quite regular South East, about 10°. Following the thread of the stream, the strata which are seen are lower in the series dipping under those on the shore. At half a mile from the coast, a softer and more red amygdaloid appears, which rests upon a bed of soft red breccia, or conglomerate, 80 feet thick, conformable to the stratification. The stream has worn itself a very deep gorge in the last-named soft beds, at the head of which it falls in one cataract, more than 100 feet. Whether this should be regarded as a true conglomerate or a semi-breccia, arising from friction I cannot determine. The pebbles are not thoroughly rounded, nor are they regular. They are mostly amygdaloidal trap, from one to six inches in diameter. The shores above the fall are of trap, elevated about 400 feet above the lake ; and adjacent are trap knobs, 200 feet higher.

Within a mile of this creek, to the West, is another of about the same size. There is a rocky islet off the shore between them. This creek is called the Kaget-she-wan-in-ewak, which, for brevity, I propose to call Shale run. There are in the heavy amygdaloidal strata, layers of soft, red and variegated shale. The descent of this creek is not far from 400 feet in the first mile. On either hand there are knobs of trap, the same as at Conglomerate creek.

MANIDOWISH RIVER.

On the Manidowish river of Norwood, which is a short distance West of the small streams just noticed, the strata are well exposed for many miles towards the interior. The section already given on page 6, to show the general structure of the country, is repeated here.

(NO. 1., repeated.)

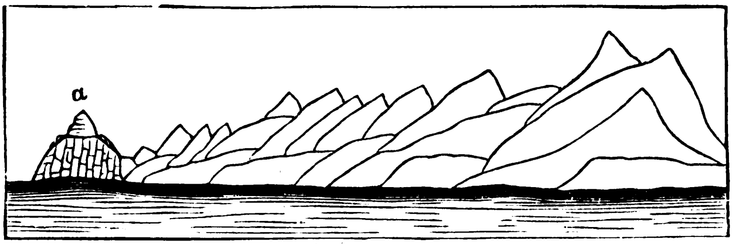


Profile of the Rocks on the Manidowish River.

This represents the entire thickness of the trap formation near its thickest part. The breccia or conglomerate layer appears again on the line of this profile. On the coast, No. 9 of the profile, is the heavy red amygdaloid trap which has already been noticed on the streams to the East. About 2000 feet in thickness is visible on the shore, but it extends beneath the lake an unknown distance, which should be added to the visible thickness. Towards the bottom there are alternations of metamorphic sand stone and breccias. These beds hold the same position in the trap of the North shore as do those of sand stone on Point Keweenaw and on the Montreal river. Next in the downward order are the two beds, 7 and 8, which are of thin altered sandstone, more or less changed; dipping with the other beds South-East by East. Beneath these lies the red breccia bed, No. 6, also conformable. In it there are large concretions, in the form of boulders, but due to chemical changes of the materials. The thickness of the brecciated layer is 50 feet. On the East there is a quartz peak similar to the one near the Kawimbash river. Beds 5, 4, 3 are of the non-productive kind, in which trap dykes are most frequent. No. 5 is red, flinty and thin bedded. No. 4 is an altered sand stone, in places variegated in color, and coarse-grained. No. 3 is a compact brick-red trap, resting upon the heavy augitic or hornblende bed, No. 2. Towards the base of the system, the dip is less in amount than it is on the coast, but in direction about the same. Between this and the main hornblende system,

is another stratum of brick-red trap, No. 1. I see nothing in the system to encourage the miner, below the amygdaloidal portion, which occupies a belt of country on and near the coast, and is therefore very accessible. To this last belt the explorer for veins and metal-bearing beds should confine his researches. From the open lake, near Two Island river, looking towards the palisades, the outline of the trap ranges is sharp and rugged, as represented below.

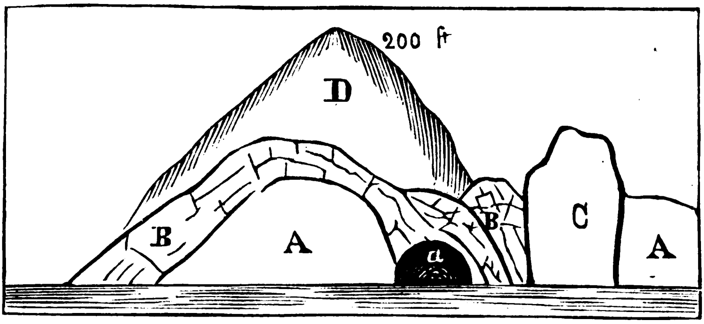
(NO. 5,)



Outline View, looking West, off Two Island River.

a, Great Palisades at Baptism River, 12 miles distant.

(NO, 6.)



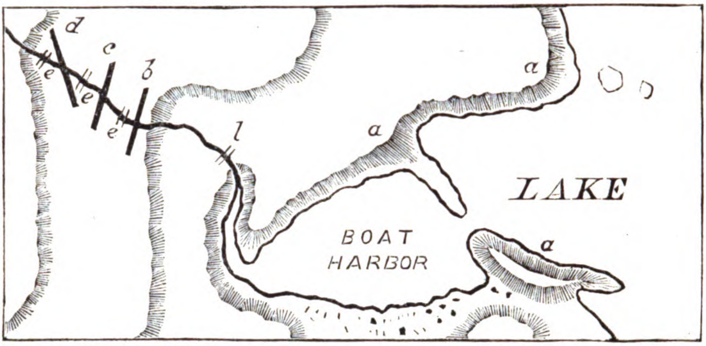
End view of a Range coming to the coast near Baptism River.

A, A, Red quartzite dome.
B, B, Red trap folding over A.
C, Vertical greenstone outburst, 20 rods thick.
D, Mountain in the rear.
a, Cavern in the soft beds, B.

BAPTISM RIVER.

Not far West of the Manidowish is the Baptism river, of which I insert a plan of the mouth, and its little harbor for boats.

(NO. 7.)



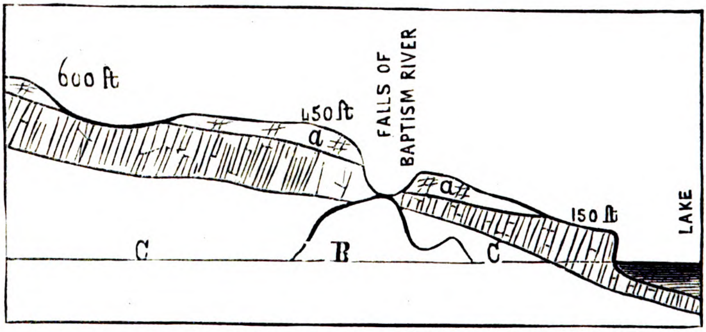
Mouth of Baptism River.

a, a, a, Palisades of red columnar trap,
b, c, Quartz dykes, North-East by East.
d, Quartz dyke, North and by East, 30 feet wide,
e, e, e. Cascades and Chutes.

PALISADE BED.

The first and second palisades are composed of one and the same stratum, of columnar trap, undermined by the action of the lake. This bed is very heavy in general 200 feet thick, dipping with the formations South-Easterly, 15° to 18°, as represented in the following profile.

(NO. 8.)



Profile of the Palisade bed, two miles North-West, dip South-East.

A, A, Brick-red columnar trap, 2d Palisade.
B, Protruding mass of quartz and greenstone.
C, C, Alternating beds of black and brown flinty trap, with amygdaloid and greenstone dipping away from B.
a, a, Drift Materials.

It is of course disturbed by the intrusive rocks, greenstone and quartz; and is occasionally cut by dykes; but the latter cause very little dislocation. There are places where the quartz has a form of crystalization; which gives it the appearance of porphyry. Near the junction of the intrusive masses, the red trap is frequently altered to clink stone, which is much jointed; coming out in thin rectangular plates, the edges of which are not affected by weather. Altered slaty sand stone, sometimes breaks into like pieces, from the effects of metamorphism; but its color is less dark, being more inclined to gray. Its grain, is less fine and its texture less flinty, although the pieces have the same rattling sound when struck, resembling that of broken crockery. Metamorphism may result from more than one cause, but the changes which are observed here in the sand stone and trap beds, seem to me to be due to contact with the heated masses of greenstone and quartz. I have seen laminated sandy clay, as much altered by the heat of a lime kiln continued through a series of years. At the first rapid is a local disturbance, where for a short distance the dip of the beds is reversed; and is very sharp to the North-West. The bearing of the beds is, however, the same. This is no doubt due to the uprising of an intrusive mass beneath; the axis of which corresponds with the strike of the beds.

The quartz uplifts on this stream assume a great variety of forms. Ordinarily it is gray, compact and vitreous. Where it comes in contact with the red and brown trap, it takes on various shades of green. It is both slaty and jointed, like the other silicious beds of the region; showing that some general cause gave rise to the fissile form of the rocks. The gray compact quartz resembles extremely that of the Penokie range in Wisconsin, which embraces extensive beds of Magnetic iron ore. On Baptism river quartz fills the dyke fissures, sometimes in company with greenstone, as frequently happens in the protruding masses. Along the valley of the creek are the usual huge boulders of greenstone, red trap, and quartz, constituting a material part of the drift. Above the falls, as exhibited in the last profile, where the channel has been worn down through the Palisades bed A, A, the bold upheavals are conspicuous.

A bed of compact trap is visible about 60 rods above, tilted to the South-East at an angle of 50° to 60°. In it are bands of flint and amygdaloid, not exceeding one foot in thickness, like those at the mouth of the Kawimbash. The course of the creek from the falls is nearly at right angles to the direction of the profile; that is to say, is nearly North-East and South-West along the bearing of the strata. At one-half mile is a show of amygdaloid with seams of laumonite, calc spar, and hornstone, from two to six inches wide. In this rock is a canon where the walls are 100 to 150 feet high. The strata are nearly level. It is the most hopeful

stratum for minerals seen on this stream. The country between Baptism and Beaver rivers is very much disturbed. The beds farther in the rear and along the line of strike to the coast, do not promise to be of much mineral value. From the headland at Beaver bay, to the Great Palisade at Baptism river, a distance along the coast of about 6 miles the rocks are almost everywhere disturbed.

Outliers of the Palisade stratum are seen on the coast from hence to Beaver bay. An island at about two miles is a part of this bed. In the third mile there are three protrusions of quartz. Between two of them is a stratum of columnar greenstone, which is very thin, and the columns being at right angles to the surface, are therefore very short but very perfect. The second island is of quartz, and the third of red trap, a portion of the Palisades underlaid by greenstone. The local profiles exhibit these outbursts in sufficient detail. This excessive disturbance, and the hard, flinty character of the strata is unfavorable to mineral deposits.

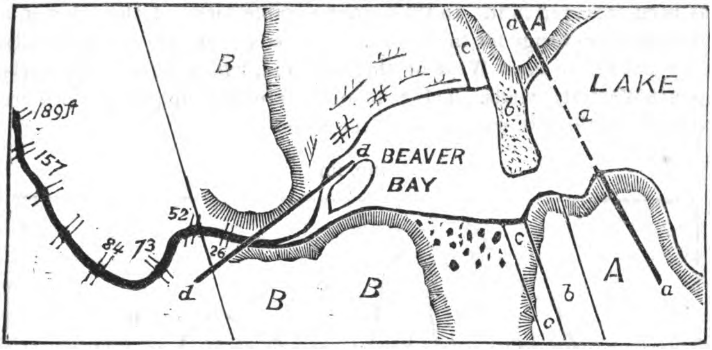
On this part of the coast there is proof that Easterly winds prevail over those from the West and South-West. The shingle for some miles to the West of the red palisade stratum, is composed wholly of pebbles of that rock. As it is very much jointed, angular pieces fall into the water, and are transported along the beach. If Westerly winds prevailed, their movement would be to the East. They are not so hard as to resist attrition a long time. Near where the rock is in place, they are of large size, and less perfectly rounded. Farther West the shore line of pebbles is less bold; they are smaller and more perfectly rounded. Finally they cease to constitute a majority of the shingle, and are found mixed with those of other and harder beds.

BEAVER RIVER AND BAY.

The plan here inserted shows a topographical resemblance between the mouths of Baptism and (Cedar or) Beaver rivers. At Beaver Bay there is water enough to admit light draft vessels, which is not the case at Baptism river.

A settlement has been formed here under the direction of the Hon. Thomas Clark, and a saw mill built. The Messrs. Wieland Brothers now occupy the place, from whence is the shortest route to Vermillion lake. Only about one mile of the stream is represented on the plan, in which the total fall is 189 feet. For half a mile farther there are chutes and rapids in deep sunk gorges, when the still water and low banks are reached.

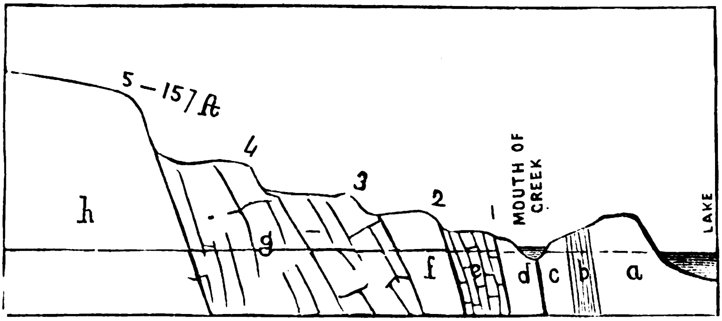
(NO. 9.)



Mouth of the Ke-shik-on-se-kau. or Cedar river, and Beaver Bay.

A, Red trap—a, a, dyke.
b, b, Slate lamina nearly vertical—strike South by West.
c, c, Flinty bed, " " " " "
d, d, Dyke East and West, 4 feet wide.
B, B, Beds of quartz alternating with flinty trap and greenstone on edge.
The figures represent the elevation of the head of each chute above Lake level.

(NO. 10.)



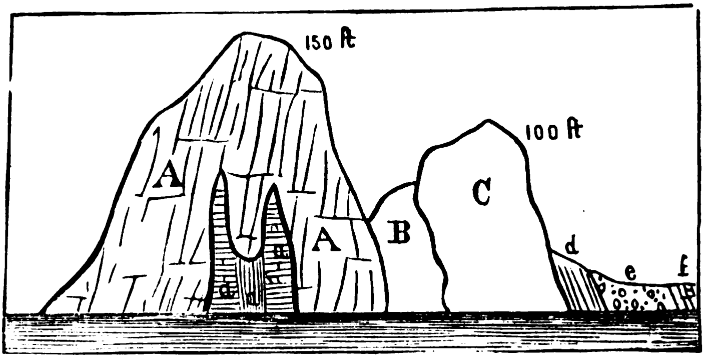
Profile at Beaver Bay. Course North-West. 1 mile.

a, Red quartzose trap. b, Silicious slate lamina, vertical. c, Black flinty trap.
d, Dark colored compact trap. e. Flinty black trap, nearly vertical.
f, Stratified quartz, dip slight South-East. g, Greenish quartz, passing into greenstone.
h, Protruding mass of greenstone. 1, 2, 3, 4, 5, Succession of chutes and falls.

These levels are 236 feet above the lake. On the banks the red clay and coarse drift rise from 80 to 100 feet above the water. There are evidences of terrific floods during which, in the narrow gulfs of the stream, the water rises 20 feet. On the coast West of the harbor about a mile, and nearly South of the mill, is a vein of iron pyrites in the greenstone; which Mr. Wieland has traced into the interior. Its bearing is

nearly North and South. It has not been opened, and as yet no copper has been observed in it. In the more favorable rocks of the interior, its contents may change for the better. The beds represented on the plan, come out to the coast West of the headland, which secures the harbor against Westerly winds. This bold and interesting upheaval is in part exhibited in the following view of the water front.

(NO. 11.)



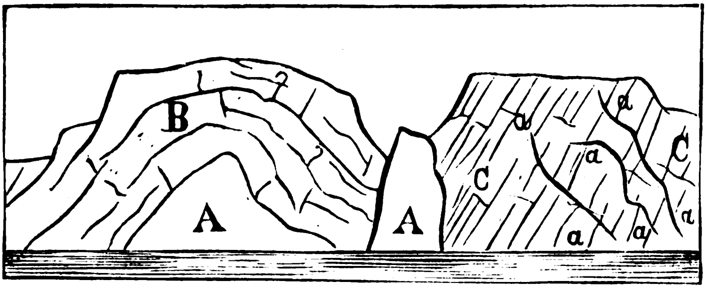
West side of Beaver Harbor, looking West.

A, A, Red quartzose trap. B, Injection of greenstone and quartz. C, Black slate. d, Flinty slate, much jointed and laminated vertically. e, Boulders. f, Black jointed trap passing into greenstone. a, a, dyke of columnar trap, not reaching the surface of A, A. Columns both horizontal and vertical.

There are, however, many other singular contortions of the strata in the vicinity. The headland shows no less than three heavy quartz dykes, to the East of the profile; some of them crossing the outer bay to the North-Eastern shore. There are instances of red quartz protrusions, in gray quartz, and also where both kinds are imbedded in greenstone. At chute No 5 on the creek, there is a disturbance by which the beds are inclined to the North-West, as they are on the Baptism river and French river. They contain a mineral resembling mica. There are, also, what appears to be injected masses of red quartz, laumonite augite, and calc spar. The deep " pot holes " worn in the rocks, and which are common in all these mountain torrents, must have required for their excavation the lapse of thousands of centuries. In a seam in the quartzose portions there is Mispickel, or the white arsinide of iron, frequently mistaken for silver. There are also in some of the joints a black, friable substance, which I take to be carbon. There are also crystals of specular iron ore.

The rocks which lie above the fifth chute, come to the coast about two miles West of the harbor, and continue thence for two miles.

(NO. 12.)



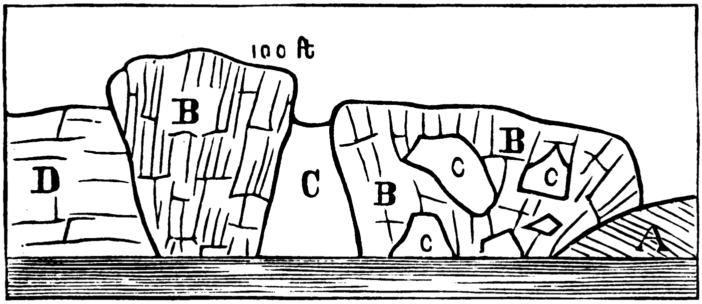
Contorted beds West of Beaver Bay, around the Point.

A, A, Protrusions of gray and green quartz. B, Crystalline or greenstone trap. C, C, Red trap, bedded. a, a, a, Veins of flint or hornstone.

In the coves a little to the East, a rocky point which the voyageurs call "Presque Isle," the beach is in places composed of augite, derived from the adjacent strata. Those beds on Cedar river, above the falls, which carry glittering scales like mica, are also seen on the coast. As I had no subsequent opportunity to examine the specimens, and saw no mica elsewhere on the coast, except in altered sandstone, I am not positive about this mineral. The greenstone strata and masses appear to be mineralogically alike. Both are inclined to be columnar; but not as perfectly so as the coarse-grained basaltic trap of the dykes. On the surface the greenstone weathers everywhere alike; showing whitish-gray spots, that result from crystallization in radii, which decompose unequally.

Another of the various forms in which quartz, altered sedimentary rocks, and greenstone are thrown together, is illustrated by the annexed view of a mural front as it rises out of the water.

(NO. 13.)



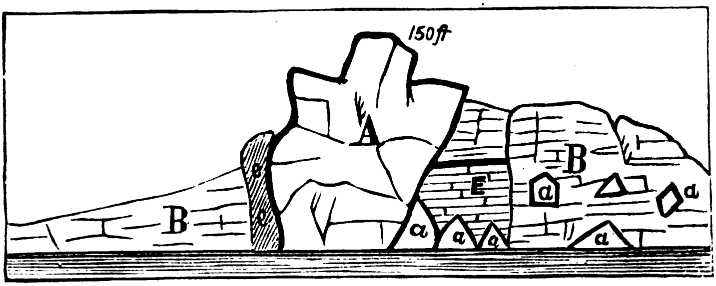
Quartz and Greenstone outbursts West of Beaver Bay.

A, Altered slaty sand stone, dip South-South-East 5 deg. B, B, Greenstone, rudely columnar in place C. C, Masses and blocks of quartz, embedded in B. D, Bedded trap.

Injected greenstone and quartz are always associated. It is possible that analysis would show that this variety of greenstone differs mineralogically from the stratified rock of the same name, but without analysis, it is not easy to decide. It is probable, also, that future investigations will show the two varieties of brown and amygdaloid trap to be both igneous and metamorphic. About Presque Isle the beds dip unequally from 8° to 15° South. They are columnar, the axes of the columns not being at right angles with the face of the beds.

At the Kana-kik-obig, or "Low Bush" river, there are regular pentagons on the surface of a greenstone stratum which dips towards the lake. For a mile to the East there are beds of coarse-grained amygdaloid with grenstone, and further East there are protrusions of quartz.

(NO. 14.)



Intrusive quartz and basalt in horizontal columns—2 miles East of Low Bush River.

A, Dyke of quartz 80 to 100 feet thick. a. a, Blocks quartzite intruding into the trap B. B, Trap, bedded horizontally. E, Columns of trap, horizontal, pentagons 2 to 3 ft. in diameter. e. e, Brecciated mass and spar.

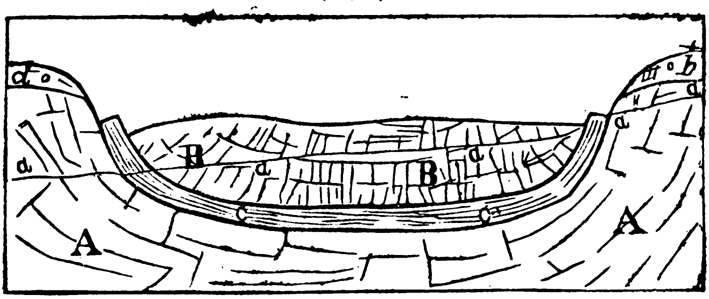
Up this creek at half a mile the amygdaloid beds appear like metamorphic sand stones. They are overlaid by red clay, and dip South-East 3° to 5°. Forty rods farther there is a red breccia, conformable to the amygdaloidal beds.

The imbedded pieces are very large; some of them in concentric layers owing to successive stages of chemical change, acting from the surface towards the interior. Examples of a new arrangement of particles, changing from compact to laminated, either in planes or curves, arising from chemical changes are often met with. The most common is the case of the kidney iron ore, of the coal series. Exposure to the atmosphere, or atmospheric influences below the surface of the earth, the lump in time becomes enveloped by a succession of coats, like those of an onion, having a different color, texture and hardness from the core.

About three-fourths of a mile are the principal falls of this stream. Here is a bed of soft, red, mottled amygdaloid, with seams of irregular veins of calc spar and laumonite, carrying carbonate of copper. There are

also in it flint-like portions, not regularly disposed. The general bearing of the rocks is as usual, North-East and South-West, but thrown up at a high angle of 30° to 45° to the South-East. There are also intercalated beds of metamorphic sandstone. In the next mile, following the stream, there are numerous cascades over similar rocks and beds of red trap, dipping conformably, but at a low angle of 3° to 5°. Between the third and fourth miles is a geological basin or trough, where the strata are sunk in the manner represented in the following cut.

(NO. 15.)



Profile along Low Bush river, 4 miles from mouth, 400 feet above lake.
A, A, Amygdaloid and brown trap. B, B, Pale brick-red trap, much jointed ver tie black metamorphic slate, 20 feet thick. a, a, a, Thread of the stream. b, b, Drift material.

The strike of the beds is not varied by this sudden folding or sinking. The sag is on the line of the profile quite cup-shaped, turning sharply up at the opposite edges. The bottom rock A, A, is favorable for native copper, and pieces of good vein rock were seen in the float material of the creek. D, D, is the usual brick-red trap of the region of which the Palisades are an example. It is every where rudely columnar, in four-sided figures, either rectangles or trapeziums, not in pentagons, hexagons, and septagons, like the black and green basalts. It has everywhere a light specific gravity, and is therefore easily transported by water. It nowhere embraces minerals of value as yet observed.

Between Low Bush and Split Rock rivers, this bed comes to the coast on the line of bearing. Here and to the westward are repetitions of the water-worn brick-red shingle already referred to. The rock being very much jointed, falls in small pieces, which are rounded by the grinding action of the waves and transported Westerly by the excess of Easterly winds. The measured thickness of this red bed on the coast is 105 feet.

Near Split Rock creek, on a flat surface of greenstone, I had an opportunity to determine mathematically the dip of the beds. The direction is here as usual East-South-East, and the angle of inclination 5°. This layer is not very thick, but is composed entirely of regular pentagonal columns of different sizes, from three inches to five feet in diameter.

ENCAMPMENT RIVER.

The space allotted to this Report does not admit of a full notice of the geological structure of this coast, which is everywhere complicated.

I am obliged to omit many local details and illustrations, and confine myself more to a general description of the rocks where it is reasonable to expect mineral. The region where the trap beds are favorable, from Two Island river to the Manidowish, has already been noticed. From Baptism to Gooseberry river, the prospect is not favorable, either for veins or beds of native copper. I do not despair, however, of the discovery of veins containing ores of copper, after thorough search and analysis.

The country is difficult of exploration, because the exposures are few, and the strata much disturbed. Through Town 53, North Range, 10° West, I saw several true veins on the coast. There is one near the range line between 9 and 10, about two miles East of Isle Encampment river; another near the line between sections 14 and 15, Town 53, Range 10, and one on the South-East quarter of 15.

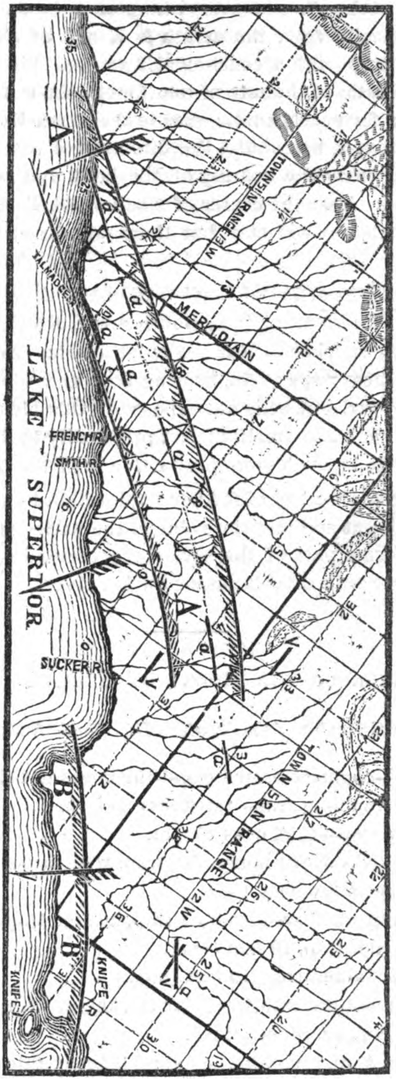
These show only iron pyrites to the eye, but when traced into different strata or followed in depth, the contents may change for the better. It is not common for a region to have true veins, and not produce some valuable mineral.

In this township the beds are less cut up by dykes, and less thrown by by greenstone upheavals, than in the township next East, or T. 54, R. 9.

On the Bitobig and on Silver Creek, in T. 53, R. 10, two miles from the coast, the Knife and French river beds, are reported to exist. I cannot verify this from observation, but those beds should pass there, unless there is a change in composition or in bearing. Patient exploration alone can settle this question. I have so often seen a break of continuity in strata, that it is not safe to infer their existence far beyond observation, even on the line of strike.

Near Silver Creek, in T. 53, R. 10, I have seen loose pieces of vein-matter containing native copper. In the North-East part of T. 52, R. 11, on the point South of Agate Bay, are light, short veins in the soft beds which show copper, but I could not connect them with a regular and persistent system. The accompanying miniature map, including the principal parts of T. 51, N. R., 13 West; T. 51, R. 12, and T. 52, R. 12, West, exhibits the copper-producing belt of ground, A A., as far as its limits are at present understood.

(NO. 18.)



Portion of the North shore in Towns 51 and 52, North Ranges 12 and 13, West; St. Louis County, Minnesota. Scale ¼ inch to mile.

A, A, Alternate bands of laumonitic and amygdaloid trap. Dip South-easterly 12 to 15 deg.—Copper bearing. B, B, Stratum of hard, crystaline trap, dip South-East. V, V, V, True fissure veins, East and West. a, a, a, Native copper in beds running with the formation. The arrows show the direction of the dip of the beds.

On the coast, at the Mocomon or Knife river, there is a heavy bed of crystaline trap, forming a projection to the West of the mouth, and extending westerly beyond the site of the city of Buchanan. It is rudely

columnar. The rocks are not everywhere seen in ascending the river. One-fourth of a mile from the mouth is a bed of close-grained, flinty, brownish-black trap, with a conchoidal fracture. Beneath this, dipping South-East by South, at the rate of one foot in six, is a soft, porous bed. Here the stream, for nearly a mile, runs to the North-East, along the strike of the beds. Above a low chute, the direction of the channel is nearly at right angles across the bearing of the beds, and several of the soft layers are visible. Near the center of Section 36, T. 52, R. 12, the rocks are partly concealed by red clay, but there are exposures of favorable brown trap.

On the South-East portion of Section 25 one of the copper-bearing porous beds crosses the river, dipping South-South-East. The copper is in small particles, in bunches of blue vesicular quartz. Near the bottom of this layer, is a heavy spar vein, bearing East and West, nearly vertical, 3 feet wide. Several soft beds are exposed in this vicinity, carrying copper in spangles, shot and small pieces, principally in bunches of white quartz. The white is much more productive than the blue quartz.

I think these beds worthy of further exploration by sinking an upright shaft, which shall cut and test the value of the series at this point. This show probably forms part of the series represented by A, A, bending a little more to the South after it passes Sucker river.

Profile of the Rocks on Sucker River.

Descending in the order of the Strata. Dip South-East, one foot in six.

1. Lake level—compact brown trap—thickness not determined.
2. Soft, red, crumbling trap—thickness 50 feet.
3. Black flinty trap—thickness 15 feet.
4. Porous reddish-brown laumonite trap, with bunches of quartz and fine copper a few feet thick.
5. Brown, compact, coarse-grained trap, 20 feet thick.
6. Compact black trap, 10 feet thick.
7. Flinty iron-stained trap, 10 feet thick.
8. Soft red laumonitic trap, irregular thickness, with bunches of quartz and fine copper, 50 feet thick.
9. Brown, firm trap, favorable to veins, 100 feet thick.
10. Soft, brown amygdaloidal trap, with laumonite and chlorite, thickness not determined.
11. Compact brown trap, 20 feet thick.
12. Soft laumonitic trap, with quartz bunches, 20 feet thick.

13. South-West quarter, section 3, T. 51, North, R. 12 West at falls; compact dark-colored trap, containing narrow vein, v, (see map) East and West, principally laumonite, 200 feet thick.
14. Soft light red trap, with quartz bunches, thickness not seen.
16. Heavy bed of firm trap, thickness not seen.
17. Compact trap, at N. E. qr. section 4, with seams of epidote and fine copper. A very heavy bed extending to S. W. qr. of section 33, T. 52, N. R. 12 West, dip regular South-East, one foot in six—thickness not determined.

No. 17, is underlaid by a soft bed, in which is a true vein, V, 15 inches wide, bearing North by East, nearly vertical, with a slight hade to the West. Vein-matter, silicious, with fine copper.

Another similar vein, 8 inches wide, nearly at right angles to this, is seen in the compact brown trap, 30 rods lower down the creek—elevation above Lake level, about 200 feet—rocks well exposed in the channel, but not in the adjacent country.

HENRY SCHMIDT'S RIVER.

The next stream examined to the West of the Sucker (or Namebin) river, is called Henry Schmidt's river, scarcely half a mile from French river. The following is a section of the strata on this stream:

Profile of the Strata up Henry Schmidt's River.

Dip rapid East and by South, estimated one foot in four or five. In descending order.

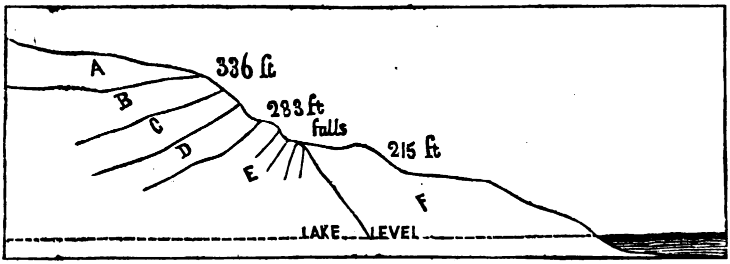
1. At Lake level, brown and dark red amygdaloidal trap, 300 feet thick.
2. More close-grained and tough brown and reddish amygdaloidal trap, favorable to copper veins; thickness not determined.
3. Trap, more dark colored and more compact, 100 feet thick.
4. Amygdaloidal trap, more soft, with silicious minerals, 30 feet thick.
5. Black close-grained compact trap, 50 feet thick.
6. Soft and laumonitic amygdaloidal, light red color, with fine copper, a metaliferous bed, 15 feet thick.
7. Hard dark-brown flinty trap, 15 feet thick.
8. Soft, like No. 6; the amygdoles being silicious, 50 feet thick.
9. Brown and dark colored compact trap, not flinty—favorable to veins—300 feet thick.
10. Black flinty trap, 100 feet thick.

11. Soft, reddish trap, laumonitic, 50 feet thick.

12. Brown and dark colored compact trap, favorable for copper, with seams, geodes and druses of vein-matter, running with the formation, and bunches of quartz carrying fine copper. Dip rapid South-East by South, by needle, one foot in four, on South-West qr. section 8, T. 51, North R. 12 West.

At the mouth of the Au Clos, or "French River," the American Fur Company had for many years a trading post. The general course of the stream is from North-West to South-East, and consequently crosses the strata at nearly right angles to the strike.

(NO. 17.)



Profile up French River by estimate 4 miles, North-West.

A. Drift clay, gravel and boulders. B. Light red trap—dip North-West, slight. C. Deep red trap—dip North-West. D, Black Slate, dip N. N. W. 40 deg. E. Altered sand stone and trap, dip reversed, strata broken and tilted both ways. F. Brown and red amygdaloid trap, coarse-grained, carrying native copper in veins and beds—dip South-East by East 12 to 15 deg. Thickness 3500 to 4000.

The series of beds included in F of the above profile, are the most promising of any I saw on the North shore. I have not been able to subdivide it into layers, and have therefore represented it entire. The "North Shore Mining Company," on the South-West quarter of section 18, T. 51, R. 12, has done the only mine work in the country; first under the direction of Capt. Parry, and afterwards of Doctor Saulsbury.

When I last saw it, in 1864, their shaft was down 43 feet in one of the metal-bearing beds, which is 15 to 17 feet thick. Its bearing is North 40° East, dipping South Easterly about 30° with the horizon. There is 12 feet of clay over the rock. The copper is in small grains and lumps in a gangue of quartz, slightly crystaline, including red porous trap. Pieces weighing several pounds have been taken from this shaft. About 12 feet below the metaliferous layer, Capt. Parry reports another very much like the first.

On section 8 what appears to be the same belt is visible in Schmidt's river. In a South-West direction on section 19 is another, which coincides in direction and in general character with the French river belt. These exposures range themselves in a line, a, a, a, upon the map, extending from the coast about 6 miles along the bearing of the strata. There are

other similar bands embraced longitudinally in the formation F. These beds are much more easily operated than veins. As masses of native copper have not been found on this coast, it is not reasonable to expect them.

At the close of this paper will be found an estimate of the cost of working mines where stamp copper only is found, and also of working veins and masses.

On French river, I saw but one true vein, which was small though it carried fine copper.

The trap at the Company's works is a good brown amygdaloid, with small, reddish spots. It appears to be the same as is seen on Sucker river.

Following up the channel, at about two miles from the coast the beds are much disturbed, but are still favorable for mineral. In some light veins of quartz, copper is visible. At about three miles the dip is reversed, as shown in the profile at E. The elevation at the head of a fall, or rather, a series of chutes, is 283 feet above lake level.

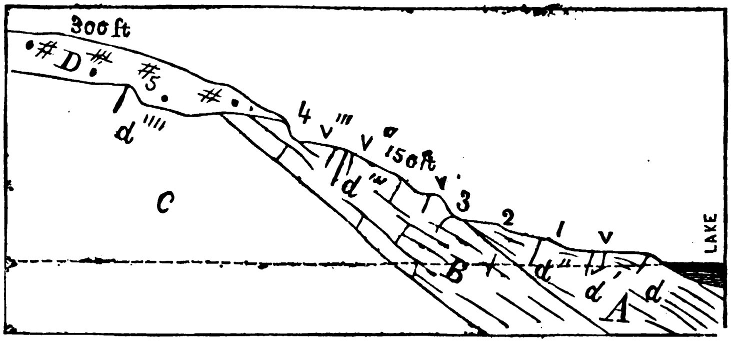
An entire change takes place in the character of the rocks, as is usual at the seat of disturbances. Here there are hard flinty beds and altered sand-stone, all dipping rapidly N. W. The beds above F, as exposed in the channel, offered no inducement to the miner. They are sufficiently explained by the profile.

In the drift bed, A, there is a heavy layer of boulders overlaid with red clay. This is what seldom occurs in the Northern drift, having been noticed but once on this coast. There are here large blocks of red laminated sandstone among the drift boulders.

HOLLOW ROCK CREEK.

The geological section gives a general representation of the rocks around Portland. At the mouth of Hollow Rock creek, about 1½ miles East of this place, the trap beds have singular resemblances to altered sandstone. I have seen similar appearances at the junction of trap and sandstone beds on Point Keneenaw, where it is difficult to say where one ends and the other begins. In places the original lamination is not wholly gone, and there are amygdoles of spar and laumonite distinctly formed. Here is a heavy bed, A, not less than 1500 feet thick, which it is not easy to say whether it is trap or sandstone. At Portland, thence to and beyond the creek are a great number of dykes of basalt, which cut the bed A

(NO. 18.)



Profile of the Rocks up Hollow Rock Creek, near Portland. Course North-West 3 miles.

A, Amygdaloidal trap and altered slaty sandstone—dip South-East by East 12 to 18 deg. B, Close-grained dark-blue trap—dip East 12 to 25 deg. C, Dark colored mass, in places slaty, like the hornblende slate of St. Louis river. D, Clay and boulder drift. d, d', d'', d''', d'''', dykes. v, v', v'', v''', Spar veins. 1, 2, 3, 4, 5, chutes in the stream.

generally in a North and South direction, and at an angle nearly at right angles to the dip of the strata. One of them is twenty feet wide, bearing North-North-East, alongside of which, on both faces, is a seam or vein of laumonite and spar. Going up the channel of the creek, at about sixty rods it is crossed by a dyke eighteen inches wide, which has a different bearing from most of the others, being North-North-West. At about one-fourth of a mile the slaty, silicious rocks are well exposed, dipping South-East by East, 15° to 18°, in which is a North and South vein of calc spar, 6 inches wide, apparently vertical. Twenty rods above it, is a North-North-West dyke in the same rock, which has produced a visible disturbance in the strata. At about half a mile from the coast is a chute of twelve feet, over the same laminated reddish-gray rocks. A few rods above this chute is another dyke. Near it is a heavy vein of calc spar, bearing North and by West, which dips westerly at an angle of 75° By estimate, at three-quarters of a mile is a chute twenty-six feet high, over what I regard as the same altered sandstone; and not far above, a third fall of twenty-five feet, where the rock is more compact and trap-like, in places amygdaloidal.

The elevation above the Lake is about 120 feet. Above this chute in a compact, fine-grained blue trap, is an East and West vein of calc spar, six inches wide. At about one mile is the same dark-blue trap, resembling trachyte, having the same thin layers and ringing sound. This rock continues for one-fourth of a mile, dipping to the East 12° to 15°. Here is another North and South vein of laumonite and spar, six inches wide, and near it a dyke four feet wide, nearly North and South, with an inclination to the West of 80° to the horizon.

Another dyke 25 feet wide crosses the creek just above the last, which is parallel to it, and only about thirty feet above the dyke is a spar vein, which conforms in direction and dip with the other veins and with the dykes. Here, and for half a mile farther up the creek, the rocks so much resemble the hornblende slate of the St. Louis river and Mission creek, that I place them in that formation, although they are much disturbed. At about 1½ miles is a chute of 25 feet fall. The elevation is here about 200 feet above the Lake, the dip of the rocks being to the East. They are overlaid in the banks of the creek by red clay and boulder drift, with large boulders of red quartz and feldspathic rocks.

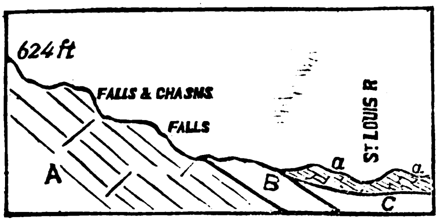
At two miles is a fall of 69 feet, where the black slate cannot be distinguished from that of Mission creek, and in which is a dyke of feldspathic material a foot wide. On the rock at the head of the fall the drift clay rises 80 feet, which I estimate to be 300 feet above the Lake. Pursuing the creek half a mile farther, the rock was visible only once, and my Indian said no more rocks were to be seen on it.

Away from the stream, surface examinations showed only the drift clay and boulders. Such a number of dykes must have produced faults in the strata, although no great dislocations were observed. The change of dip from South-East to East could only occur from an upheaval not far to the North of Portland. On the shore of the bay inside of Du Luth, and also on the coast outside, the trap beds are very irregular and changeable. There are joints, seams and wrinkles in the beds containing spar, chlorite and epidote. There are also amygdoles of quartz.

The rocks in the space of a few rods, present several varieties of trap—the augitic, flinty and amygdaloidal. This changability and disturbance is adverse to the existence of valuable veins of native copper. The contents of the veins themselves are principally spar, without visible copper, but further search should be made for mineral-bearing lodes, such as arsenides and sulphides—for these the rocks are more favorable. In the Spring of 1858 a boulder was found on the North shore of St. Louis river, at Rice's point, below Oneota, having a metallic appearance, with a pale brass color, and which weighed about one hundred pounds. Various accounts have been current as to the locality of this mass. Mr. R. B. Carlton said it was found by Joe Posey, soon after the Spring freshet, in the sand at the place just named. In size it is about a foot long, with two faces nearly parallel, as though it came from a vein with regular walls, four or five inches wide. Some persons regarded it as an artificial alloy of zinc and copper, which had been produced by melting a church bell. It is broken without difficulty, and in the interior has patches of a greenish tinge. The mass has a whitish-yellow color, a pyritous aspect, finely crystalized with small blotches of spar, showing it not to be an artificial

compound. As I was sending a box of minerals to my friend J. H. Boalt, Esq. at the School of Mines, at Freyburg in Germany, a piece of this boulder was forwarded, with the request that it should be analyzed. No arsenides of copper were then known on Lake Superior, but I have since seen a specimen from Portage Lake. Mr. Boalt reported that about the time of the arrival of my specimen another was received from Chili, in South America. All parties were interested to know what ore of copper they represented. The analysis gave eighty-three per cent. of metallic copper and seventeen of arsenic, which approaches very near to a rare mineral, the Algoderite of Dana. This boulder no doubt came with the drift materials from the North-East, and represents a vein somewhere in that direction, perhaps not far distant.

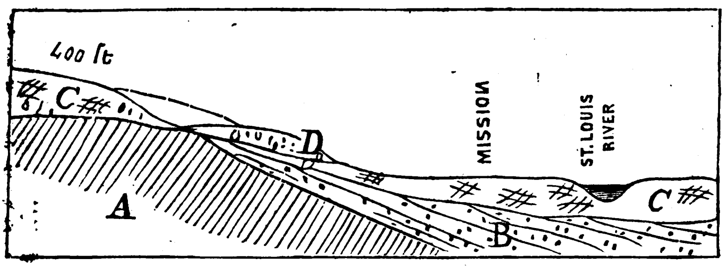
(NO. 19.)



Profile up Quartz Creek, near Oneota.

A, Thick bedded quartz, dipping South-East 10 to 12 deg. 1320 feet in thickness visible. B, Hornblende rock. C, Potsdam sandstone. a, a, a, Red drift clay.

(NO. 20.)

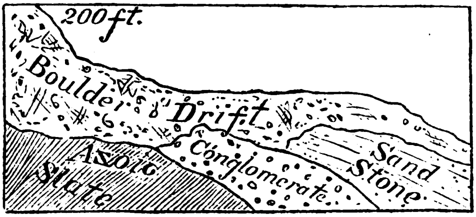


Profile up Mission Creek at Fon du Lac. Course North-West. Distance 3 miles.

A, Hornblende slate. B, Potsdam sandstone, dip South-East, variable 5 to 15 deg. C, C, Red drift clay D, Coarse boulder drift.

ST. LOUIS RIVER.

No. 21.



Junction of the Sedimentary and Metamorphic Rocks, St. Louis River, Min.

For want of space I can not go into details respecting the country between Portland and the Falls of St. Louis River. A general idea of the order of succession in the rocks will be obtained from the three last profiles.

The conglomerate dips between south and south-east 5°, with pebbles of flint in the lower part. There are also oblong pieces of the black and green slates in the conglomerate near the junction. At the contact the slate is slightly reddened; with zigzag suture like veins of quartz. The slate is here very much jointed so as not to furnish plates or slabs. In a creek with a valley three hundred feet deep, one mile northerly of the junction, is the black slate, apparently an hornblende rock rising one hundred feet above water level, covered by drift deposites. Lamina vertical.

At the upper end of Grand portage the drift bluff is 68 feet above the river. According to Nicollet this landing is 984 feet above the ocean, which makes it 374 feet above Lake Superior. From the foot to the head of the portage I estimate the fall in the river at 297 feet.

Below the landing about forty rods, is a vein of ferruginous quartz four to six inches in thickness, strike west and by south. Lamina of slate vertical, dip of the bedding of the rocks which I regard as the stratification, south and by east 75°.

These slates are not entirely regular in composition or structure, being in some places compact. There is a vertical dyke ten feet wide near the landing with small quartz veins, spar and iron pyrites.

The slates are worthy of being tested by practical men for roofing purposes. They are somewhat hard, their composition being principally silex, but they will be exceedingly durable and are not so tough but they may be wrought. The quantity is inexhaustible. One half mile above Womans portage, is a collection of quartz veins on the west side of the river, and one quarter of a mile further up the stream, are the same rolling or waving strata, as were seen along the rapids.

By estimates, the descent of the river over slates from the upper to the

lower end of Knife portage, is thirty (30) feet, and from the foot of the Knife to the head of the Grand portage, also thirty (30) feet. The several rapids from Knife portage to Ashkebwaka, I estimate at sixty (60) feet, and thence to the mouth of the East Savannah river twenty-five (25) feet, making five hundred and ninety-four (594) feet above Lake Superior and 1204 above the ocean.

ESHQUAGEMA LAKES.

The first of the Eshquagema lakes has low shores, rising but a few feet above the mouth of the Embarras river. At second lake is a mass of boulders including, in addition to the northern igneous and metamorphic rocks, many of silurian lime rock.

There are seven of these lakes with low rapids and portages between. The adjacent drift hills rise from 100 to 200 feet on the west side of lake No. 4. They rise still higher on both sides of No. 6, constituting the Mesabi range, which is 400 to 500 feet above water level.

The Vermillion river portage commences between the hills on the west side of No. 7. Ascending the drift hill nearest lake No. 6, I found a bare peak of sienite in place at the summit, the first rock in place above the East Savannah river.

It rose as a bald crown, surrounded nearly to the top with large boulders of northern rocks. The highest part of this knob is scoured, scratched and polished by the drift glaciers. There were some peaks on the east apparently 100 feet higher, rising according to my estimates 1136 feet above Lake Superior or 1745 above tide.

In the far distance to the north-east, are mountains higher than those near the portage. The trail to Vermillion river passes through a low place in the range where there are low exposures of hornblende rocks in place. There are several bad swamps on the portage. About two miles from the lakes saw a low uplift of sienite and immense numbers of boulders of hornblende, quartz, granite and sienite. Vermillion river is at west end of portage 75 links wide, with much water and apparently about the level of the Eshquagema Lakes, distance 13 poses or about four miles.

Proceeding down the Vermillion, the country is very much like that around the lakes on the Embarras. At about five miles by stream, a rapid over red sienite descending twenty feet in 60 rods around which is a portage. The next series of chutes descend about 30 feet; below which the river expands to a width of 5 chains and sienite is again exposed. At about seven miles there is a low rapid over, gray compact quartz, just above which is a small creek on the east side.

At ten miles another rapid of a few feet, and a mile below mica slate rocks in place, with quartz veins dipping north at a steep angle. Rocks are seen occasionally for four or five miles along the stream, and at about fifteen miles from the Vermillion portage, is a compact bluish quartz, very fine grained like novaculite, in layers one to four inches thick. This is about four miles above the lake and above a portage of 60 rods in length. Just before entering the lake there is a fall in the river of 16 feet, with a bold exposure of fine grained micaceous rocks, the trend of which is east and west, the structure becoming more slaty.

Coasting along the sinuosities of the shore to a long point of land on the western side about eight miles, the micaceous rocks become more talcose in appearance and more slaty, the bearing of the lamina being north east by east, and the dip northwesterly 75 or 80°. There are numerous joints which give rise to rhomboidal plates.

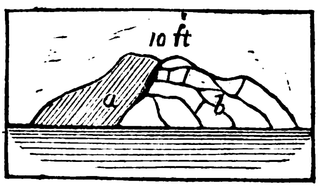
Around the bay between the recent post of the Hudson Bay Co., and that of the American Fur Co., these rocks prevail, containing veins of white quartz sometimes stained with iron. The glacial grooves very distinct here and bear south 5° west by needle. Water of the lake shallow, warm and stagnant. Fish plenty.

This lake is a perfect labyrinth of bays, points, and islands.

VERMILLION LAKE.

Sept. 1*st*, 1848.—Followed a generally north westerly course among the islands, with a view of finding the outlet. The rocks are variable, hornblende, slaty and compact, talcose slate, mica slate, granite, sienite and quartz. The islands are low, not exceeding 100 feet and rocky, and also the shores near the lake; with little soil. The granite appears as a protrusion in the slates and is therefore more recent.

No. 22.



Junction of Granite and Hornblende Slate, Vermillion Lake. *a*, Hornblende Slate. *b*. Granite.

No. 23.

Vermillion Lake. Veins of Sienite and Granite, in Hornblende Slate.

Mica is seen in the slates near their junction with the intrusive granite and sienite. Found the outlet which is visible only a few rods. For

about five miles the rocks are one half slates and half intrusive, in the form of bunches, domes and vein like ramifications. A rapid of thirteen feet fall occurs near the outlet, over granite. About five miles down the stream another, two poses in length, and a portage for goods called a "decharge," the canoe passing over the fall, which is nine feet over granitoid rocks. Three miles below is Rush Lake. The rocks in this distance are principally mica slate. At the first rapid about one mile below the last decharge, the strike of the rocks is south west by west, dip north west by north 45°, filled with veins, beds and plates of quartz and granite. One-third of the mass is quartz, forming a part of the stratifications.

The total fall from Vermillion to Rush lake is about thirty-five feet. There are low mountains visible to the west, ranging north east and south west. On Rush lake, which is a mere enlargement of the river, about six miles long, the mica slate beds are occasionally visible with the same north east and south west bearing, dipping north westerly.

At the outlet is a series of chutes over red sienite, of twelve feet descent. A granite hill on the north rises one hundred feet above Rush lake, from which low ranges are visible on the east, of about the same height. On the top of it are boulders ten feet in diameter. In a long rapid, and a very bad portage of one mile there is a fall of seventy-eight feet where granite is visible.

CRANE LAKE.

Sept. 4th.—At three and five miles below Rush lake, red granite rocks are seen, and at ten miles, a repetition of the mica slates, with quartz veins and granite protrusions, lamina vertical, strike south east. At 6, 9, 10, and 13 miles, the same rocks, dipping north easterly, with veins and horizontal bands of quartz. The rocky ranges do not rise high above the stream.

River very crooked, with frequent low rapids. For seven or eight miles below, the banks are swampy, and no rocks visible. From thence to the Crane lake portage, about eight miles, there are many rocky projections, mural faces, chasms, falls and rapids.

The main fall is thirty-one feet over mica slate, where the river passes through a chasm twelve feet wide. The slate comes apart in rhomboidal blocks, the planes of which dip south east about 45°. Here are the same plates and veins of quartz noticed above, with granite protrusions, the rocks mostly bare.

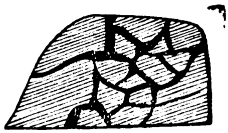
Crane Lake Portage.

This rapid is through a straight canon twenty-five to thirty feet wide with vertical walls of mica slate and granite fifty to sixty feet high. It is one mile in length and the descent is thirty-five feet. The canon, in which the water is very deep, appears to follow a large dyke bearing north west and south east. The strike of the rocks is north east and the dip south east from 30 to 50°. Crane lake has a rise and fall of six feet, the Vermillion river passing through it into Sand Point Lake. At the outlet there are repetitions of the mica slate beds in wavy layers, dipping north westerly 30°, 40° and 50°, with quartz veins and granite.

No. 23.

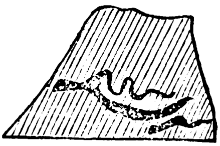
Quartz Veins in Mica Slate, Crane Lake.

No. 24.



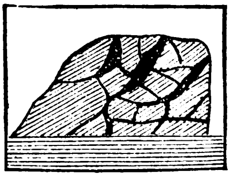
Veins of quartz and granite in Mica Slate, Crane Lake.

No. 25.



Quartz veins in Slate, Sand Point Lake,

No. 26.



Veins of quartz and granite in Mica Slate, Sand Point Lake.

On the irregular shore and the islands of Sand Point lake the rocks are bare, rising 100 to 150 feet. There is a canoe channel from the Passabikong or Sand Point Lake, to Lac Travers, over quartz and feldspar beds. Variation of the needle 9° 35 min. east. The same associations of mica slate, quartz and granite continue through Sand Point and Traverse lakes; with bare rocks and stinted pines on all sides. A portion of the quartz is intrusive like the granite and produces dislocations.

In the granite there are brilliant plates of silvery mica and large pieces of feldspar.

Glacial stria north east and south west. The slate at Snake Point resembles that on the St. Louis river.

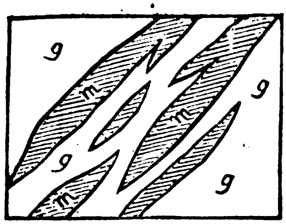
From Lac Travers to a small creek emptying into Namekon or Sturgeon lake is a portage of thirty rods, and a fall of nine feet. Vermillion river passes out of Sand Point Lake near the south end on the east side.

Passing down the creek, we reached Namekon or Sturgeon lake, in about two miles, making one short portage. Large pieces of flesh colored feldspar are seen about the head of the creek, also silvery mica. On the portage are fine specimens of tremolite and feldspar. The slates also become more solid, their lamination nearly vertical with a slight inclination north.

Sturgeon lake opens into Rainy lake from whence no high land is visible. The strike of the slates is here north east, the dip of the lamina easterly 80 to 85° with the horizon. Glacial etchings on the numerous granite islands are very distinct, bearing north east and south west. There are broad seams of compact feldspar and large specimens of silvery mica.

Large blocks of granite have been pushed up from the lake on to the rocky islands by the expansive force of recent ice. I estimate the elevation of Rainy lake above Superior to be 470 feet. Granite is frequently seen on the islands in masses which appear to be injected into mica slate. There are also pieces of mica slate enclosed in granite, thus—

No. 27.



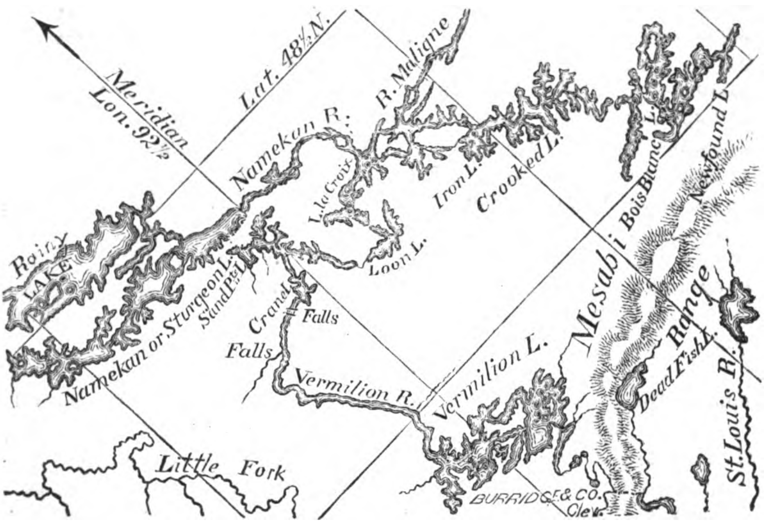
Mica Slate enclosed in granite, Rainy Lake. *g, g. g,* Granite; *m, m, m,* Mica Slate.

Sept. 8th.—Continue our course through a labyrinth of points, bays and islands. The islands are low, without soil, the bare rocks everywhere visible. The shores are without beaches, sand or pebbles, the superfical materials having been cleaned off by drift action. During the entire day passed among small islands of mica slate, granite and talc slate. They are true domes or "Roches Moutonne" scoured and polished by ancient glacier motion during the general ice period prior to the existence of man. The geology of this lake is complicated like its topography. It presents an irregular mixture of the metamorphic slates, quartz and granite, like molten overflows. No mountains. Glacial stria bear south west by south, to west, south west, and are very well defined. Dip of the slates northwesterly 30° to 80°, the strike west south west. Towards night, moving westerly during the day, the slates became more quartzose with specks of iron pyrites. The domes well polished and striated. Near the outlet there are islands of sienite and talcose slate, also red granite.

Sienite and granite enclosed in the talcose rocks which change to hornblende slate, bearing south west and north east.

At the falls of Rainy lake river hornblende slate, descent of the stream eighteen feet in one chute. Drift clay visible again with boulders of northern rocks including limestone. Country about the Fur Co.'s post flat and swampy. Proceeding down the river, which is as large as the Upper Ohio, the rocks in place disappear and the laminated ash colored drift clays of the St. Louis river are conspicuous in the banks.

No. 28.



Region of rocks and water beyond the Mesabi Range—From Nicollet's Map.

After leaving the Company's post at the Falls, the Rainy lake river is a large and navigable stream, as far as we followed it, to the mouth of the Great Fork on the Grande Fourche of the French. On both shores and for some distance up the great Fork are trees which belong to a more southerly climate, such as Oak, Elm, Linn and White Maple. Here is quite a tract of agricultural land where Grass, Barley, Wheat, Oats and Indian Corn can be raised.

In ascending the Grand Fourche, the general course of which is from south to north, the first rapid and portage was met with at about ten miles up the stream. The water was very low, and rapids and shallows were numerous from thence to its source. At 15 miles from the mouth is another portage, and again at 30 miles. Rocks in place are first seen at about 35 miles, consisting of granite mica slate and greenstone, causing low

rapids. The drift clay of the banks is like that of the Upper St. Louis. Soil good, producing coarse native grass and wild hops.

There are numerous fragments of lime rock in the drift gravel, containing trilobites and other Silurian fossils. Hight of banks 30 to 35 feet—only low exposures of the rocks in the stream overlaid by the drift and polished by the drift forces. Timber of the adjacent forest heavy. An Indian who hunted between the Great Fork and the Lake of the Woods, said there are no mountains or high hills in that region, but plenty of small lakes. We estimated the distance to the west fork of the Grand Fourche which heads near Red lake, to be 40 miles. About five miles above is a fall of 29 feet over gneiss and mica slate. Its latitude is 48° 13m. 59s north, It is here the Sturgeon are stopped in their ascent of the river. On the banks the drift bluffs rise 60 and 80 feet—strike of the beds north-east and south-west. In the slate are the same quartz and granite intrusions which are so conspicuous on Vermillion Lake. There are chutes and rapids for one-fourth of a mile, above which is still water. Timber on the banks, Ash, Elm, Linn, Aspen and White Cedar.

By stream it is about 30 miles from the great fall to the next exposure of rock where there is a rapid of four feet fall over hornblende slate. Seven miles further up the channel is a fall of six feet over trappose rock. The total rise from Rainy Lake river to the head of this chute is about 70 feet.

The hornblende slate is more fibrous than laminated, with horizontal joints. There is so little exposed that its general bearing can not be well determined but appears to north-east by east, corresponding with the Rainy Lake and Vermillion River district. No doubt the same rocks appear on the Little Fork of Rainy Lake river which is about midway between Vermillion River and the Great Fork. The trappose or greenstone exposures are inclined to be columnar and fibrous. Very light but distinct glacial etchings are visible on these rocks, their bearing being west by needle. Both the lamination, the fibres and the indistinct columns dip and point parallel to each other, west and by south 75° with the horizon. This shows that these various forms are due to a common cause.

These are the last rocks seen in ascending the Grande Fourche, and, indeed, until after crossing the low drift summit into the Mississippi and descending thence to the Falls at Pokegoma. The exposures are so few that little could be learned of the mineral value of the rocks. They resemble, however, those on Vermillion Lake and River, and no doubt underlie a large tract of country between that lake and the Lake of the Woods.

No evidence was obtained in reference to the extent of the Mesabi Range westward, and no signs of mountains were seen along the watershed dividing the valley of the great Fork from that of the Mississippi.

As I have already stated there is a large area in Minnesota where the rocks which are not concealed by drift materials, answer to the gold bearing series. Unfortunately they seldom rise above the water level. On Vermillion Lake and River, where they are better exposed, the aggregations of quartz and pyrites are in a favorable form to carry the precious metals.

Ledges, flattened layers and plates of quartz have proven in other countries to be richer than fissure veins. Of the value of this region as mining ground I am not able to express an opinion for the reason that little is known of the continuity of the quartz beds, the per cent. of metal or the expense of working. Mines of gold which always include some silver are proverbially irregular in their contents. What I shall add in reference to the cost of mining, copper bearing deposits will be something of a guide to the expenses in gold bearing quartz.

On the north shore of Lake Superior what I have briefly said upon the Knife River and the Two Island River district is sufficient to warrant fair expectations in that quarter. The tendency of every year's progress in mining is to cheapen the process of extracting the metals. In other countries it is by no means from rich mines only that dividends are obtained. Large and regular deposits where the yield is low often produce more profit, than irregular ones with rich bunches and barren spaces between.

COST OF MINING COPPER.

I have no personal observation upon the expense of working copper mines on Lake Superior since the year 1856. Improved machinery for both stamping and washing introduced since that year, would have lessened the expenses, if labor and supplies had not increased in price. The yield of the washing floors from stamp stuff, has also been increased by washers that clean the rock more thoroughly. In the mode and expense of sinking, driving and stoping, no change has occurred. On the north shore, no mine work has been done on true veins, and very little upon the metal bearing beds. As a general rule the metaliferous layers can be worked cheaper than the veins. At the Copper Falls mine in 1860, where the rock yielded one and one-quarter per cent. meagre profit was derived. Metaliferous beds have been worked at the Phœnix, Quincy, Pewabic and Carp Lake Mines. The best show at present known on the north shore is the French River District, where the most promising deposits are found in layers conformable to the strata. Where the metal bearing layers are two or more feet in thickness they should be worked cheaper than true veins in the same kind of rock. In general the beds are more regular in their yield than veins. When the stratification is understood, they can be calculated upon to extend more regularly into the earth whereby the plan of a mine is more simple. After the shafts and levels are made and the mine opened, the cost of stoping is much less, because miners reckon by the running fathom without regard to thickness. The only place on the north shore where a shaft has been sunk on a metal bearing bed, is at the works on Sec. 25 T 52 N R 13 West on French Creek, which, when I last saw it in 1864, was down only 43 feet, a depth which is not sufficient to show the average cost of sinking. By following the dip of the beds with inclined shafts, it should not exceed the average cost on the south shore. In the French and Knife River District, the trap rocks do not rise much above the surface of the country, and are generally covered by drift clay and gravel.

Little drainage can be had in such a country. It will be necessary at the outset to provide for raising the water and the mineral by steam or water power. The average cost of sinking by contract where the owners clear the mine of water and rock, derived from actual results in six working

companies in 1854, was ($13,72) *thirteen dollars and seventy-two cents* per foot The average cost of driving was ($7 53) *seven dollars and fifty-three cents* per foot, and of stoping ($19 72) *nineteen dollars and seventy-two cents* per fathom, where the mine is in a true vein. In estimating the yield and per centage of a mine, the vein matter is reduced to tons, and thus, in proportion as the vein or layer widens out, the more tons will a running fathom produce. The rate of increase may be seen in the following table:

Thickness of the Vein or Bed.	No. of Tons per fathom.	Cost per Ton at $15,00 per Fathom.
Six inches,............................	1.62	$9.20
Twelve inches,........................	3.24	4.63
Two feet,..............................	6.48	2,31
Six feet,..............................	10.44	0.77

The expense of working up a ton of rock through all the manipulations, in a mine that pulverized and washed 17,112 tons of vein matter in a year. was in 1855, ($11,33) *eleven dollars and thirty-three cents.* This includes interest on capital, depreciation of machinery, surface expenses, stoping and barreling.

It also includes cutting up and raising masses of copper. The object of the calculation being to determine the cost of working stamp stuff only, and what is the lowest per centage which will pay, the whole expense of the mine is charged to stamp work.

Nine thousand one hundred and eight (9,108) fathoms of ground had been stoped when the estimate was made. In Cornwall the price of sinking, determined by a general average, is ($7.00) *seven dollars* per foot, of driving ($3.50) *three dollars and one-half,* and for stoping (12.00) *twelve dollars* per fathom. There, although labor and machinery are cheap, the vein matter is very poor. After it is broken and sorted by hand at the mineral pile, the average yield in refined copper is only six to seven per cent. This, applied to the ground stoped, is only a fraction of one per cent. A vein or bed which yields *two per cent.* of ingot copper, produces forty pounds to the ton of vein matter, the value of which depends on the market. In general, this metal rises in consonance with the price of labor and supplies. Copper has been as low as seventeen cents per pound at New York within ten years, but ordinarily before the war twenty-three to twenty-five cents. It has risen temporarily to fifty cents. A mine in the French River District, within three miles of the shore, working a metaliferous band should be wrought on a large scale, at less than ($10.00) ten dollars per ton, and consequently should pay dividends if the yield is not less than two per cent. and the market value of copper not below twenty-five cents per pound. Dividends have been made in the Point Keweenaw District on a yield of one and a half ($1\frac{1}{2}$) per cent.

In estimating the expenses of working a copper mine, the distinction between *beds* and *veins* must always be kept in mind. There are deposits of mineral that lie in bunches and sheets between beds of rock, which are not veins or beds, and which are so irregular as to preclude a calculation upon their value until they have been wrought. These are called contact deposits and stock-werks.

The mineral in true veins exists in fissures of the rocks, which have been filled by a process not fully understood, with materials different from the wall rock, but derived from it. Veins exist in parallel groups, having a dip and bearing which is conformable to each other over certain districts. Such a collection of veins forms a system, and thus when a new vein is discovered its dip and inclination can be inferred at once. There may be in the same district more systems than one, and one set of veins may be of more recent origin, carry different mineral and have a different bearing and dip from another. The more recent set cuts through the others, but have a parellelism among themselves. Dykes differ from veins in being fissures filled with basaltic trap, the filling being effected immediately by injection of molten matter from beneath. The same strain and agitation which causes cracks in the strata, forces the substance of the dyke into the fissures, where it cools rapidly generally, assuming the form of columns with five, six or seven sides. Dykes occur more frequently in flinty and close grained trap than in the softer brown amygdaloidal variety. They carry no mineral of value, though a vein may form along the sides or near to them, and be parallel. In general, dykes disturb the veins where they intersect. Dykes exist in systems like veins, but on a more extended scale. Both veins and dykes cut the strata without regard to its bedding. On the north shore of Lake Superior there are multitudes of both kinds of fissures, giving great complexity to its geology. Veins are filled by a process that does not appear to be rapid, but by an action resembling that of chemical solution and affinity. This is probably due to electro-magnetic agencies operating slowly during great periods of time. The same quiet but efficient power partially dissolves the wall rock adjacent to the fissures, thus making for itself space in which to deposit mineral. Fractures which were originally very small, are thus enlarged as the mineral increases. The mysterious force of crystalization, due no doubt to electrical agents, expands the fissure as water does when it freezes in narrow crevices.

CLEVELAND, OHIO, May 1st, 1866.

THE GRAND TRAVERSE REGION.

A REPORT

ON THE

GEOLOGICAL AND INDUSTRIAL RESOURCES

OF THE COUNTIES OF

ANTRIM, GRAND TRAVERSE, BENZIE AND LEELANAW

IN THE

LOWER PENINSULA OF MICHIGAN.

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PREFACE.

The following report has been drawn up for the purpose of directing attention to the most remarkable and desirable section of country in the Northwest. Emigrants and capitalists will equally find in it statements of facts which will both surprise and interest them. I have no fear of being charged with overdrawing the picture. I have only given facts, figures and vouchers. They speak for themselves. The details of the geology of the region have never before been worked out, and will prove of interest to a large class of readers.

This region, like all of Northern Michigan, has heretofore been generally misrepresented. I gladly except from this charge the account drawn up by Hon. D. C. Leach for *Clark's Gazetteer of Michigan;* an interesting and extended statement which appeared in the *Grand Traverse Herald* for March 4th, 1864, and the address of D. B. Duffield, Esq., on the "Undeveloped Regions and Resources of the State of Michigan," as well as the various pamphlets and essays of Edgar Conkling, Esq., of Cincinnati, and George S. Frost, Esq., of Detroit.

In the prosecution of my work I have been greatly aided by the courtesies and liberality of the citizens of the region—especially of some whom I would be glad to name if justice only had to be consulted in the matter. I was accompanied during more than half of my explorations by A. de Belloy, Esq., of Sutton's Bay, who will be glad to reply to any inquries respecting the region. I cannot forbear to mention the great aid I have received from the exact and reliable maps of S. Farmer & Co., of Detroit. Farmer's Sectional Map has been my pocket companion in all my travels in various parts of the State for the past

eight years, and I have learned to rely upon it implicitly even to the obscurest highways and the meanderings of the smallest creeks. Many of my meteorological data have been taken from the published observations of the Smithsonian Institution. The original and published maps of the Lake Survey have been freely submitted to my inspection through the courtesy of Colonel W. F. Raynolds, Superintendent, and I am indebted to A. S. Packard, Jr., M. D. of Boston, for the identification of the canker worm moth of the region.

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THE GRAND TRAVERSE REGION.

I. THE NAME.

The early French *voyageurs* in coasting from Mackinac southward found two considerable indentations of the coast line of Lake Michigan on the east side, which they were accustomed to cross from headland to headland. The smaller of these they designated "La Petite Traverse" and the greater, "La Grande Traverse." These names were transferred to the two bays known as the Little Traverse and Grand Traverse Bays.

II. GEOGRAPHICAL POSITION.

Grand Traverse Bay is a bay of lake Michigan, indenting the northwestern shore of the southern Peninsula of the State of Michigan. Its general direction is from north to south. Its mouth is in latitude 45° 15′ north, and its head in latitude 44° 45′ north. Its length in a straight line is therefore 34.75 statute miles. The undefined region bordering on this bay is generally known as the Grand Traverse Region. The county of Antrim lies upon the east side of the bay, the county of Leelanaw on the west, and the county of Grand Traverse on and about the head of the bay. The counties of Benzie on the west and Kalkasca on the east of Grand Traverse, may be regarded as lying within the same topographical and hydrographical area; and in their geological and physical features belong to the same district.

Leelanaw county occupies the triangle lying between Grand Traverse Bay and lake Michigan. Grand Traverse county embraces the tongue of land which bisects the southern half of the bay, and extends northward to embrace about nine miles along the eastern shore of the bay. Benzie county lies upon lake Michigan. Kalkasca county is reached by navigable water only in the northwestern corner, through Elk and Round lakes. The southern limit of the region thus indicated lies in latitude 44° 30′ and the northern limit in latitude 45° 15′ north.

III. HYDROGRAPHY.

Grand Traverse Bay is a sheet of navigable water about thirty-three miles in length with an average breadth of about eleven miles. The southern portion of the bay is divided into the east and west arms by a belt of land from one to two miles wide and about seventeen miles in length, known as "the Peninsula." The east arm has an average width of about four and a half miles; the west arm is somewhat wider. The height of the bay and of lake Michigan above the level of the sea is 578 feet. The depth of water in the bay is generally from 20 to 70 fathoms. The east arm attains the greatest depth, being about a hundred fathoms at a point opposite Old Mission and thence as far as Petobego Lake. The maximum depth is 618 feet, and is found opposite Birch Lake and on a line between Old Mission and the north end of Elk lake.

The entire bay constitutes a harbor secure from all except northerly winds; while the two arms of the bay are not seriously disturbed by storms from any direction. The shores of the bay however, present a number of harbors in which vessels may at all times lie with the utmost security. Entering the bay at its mouth and proceeding along the western shore, the first important harbor reached is Northport which opens towards the south—being separated from the bay by a tongue of land called "Carrying Point." This harbor is about two miles wide and nearly three miles deep and is a frequent resort of vessels overtaken by storms upon the lake. The water is sufficient for the largest vessels which navigate the lakes.

Proceeding southward, twelve miles from the mouth of the bay we reach New Mission Harbor, also opening southward and separated from the bay by Shobwasson Point. This harbor is a mile and a half wide and a mile deep, with an abundance of water for safe navigation.

Four miles further south is Sutton's Bay, opening towards the northeast, and separated from the West Arm by Stony Point. This harbor is three miles long and a mile and a half wide with plenty of water.

Lee's Point, eleven miles from the head of the West Arm forms another shallow harbor.

Bower's harbor, on the west side of the Peninsula, opens to the southwest, being isolated from the West Arm by Tucker's Point. Off this point, and connected with it by a reef, is Harbor Island—practically extending Bower's harbor to the length of over three miles, while its width is about one and a half miles.

On the east side of the Peninsula, near the point, is Old Mission harbor, having a capacity of about one square mile. Further than this the configuration of the shore of the East Bay affords no harbor worthy of note.

Passing southward from the mouth of Grand Traverse Bay along the shore of lake Michigan, we find a broad indentation at the mouth of Carp River, opening towards the northwest and partially protected from west and southwest winds by Mount Carp.

Between Mount Carp and North Unity is a broad bay about five miles deep, affording protection from all winds except those proceeding from the north and northwest.

Between North Unity and Sleeping Bear Point is another broad bay about four miles deep, forming the harbor of Glen Arbor, affording shelter from all except north and northwest winds. The mouth of this harbor opening towards the Manitou Islands about nine miles distant, it receives considerable protection from heavy "seas" approaching from that quarter.

No other natural harbor of importance exists along this shore; though improvements, some of which are now in pro-

gress—as at the mouth of the Bees Scies River—will create harbors equal in excellence to any in the region.

The Grand Traverse region is remarkably provided with navigable inland lakes. Some of these connect with each other or with the bay or lake Michigan in such a manner as to constitute extended channels of inland communication by water. Connecting with the East Arm of the bay through Elk river is Elk lake, a body of water about ten miles long and averaging a mile and a half in width. Passing from this we enter Round lake, about one-fifth as large, from which we proceed northward to Torch lake, the largest in the region. This sheet of water is eighteen miles long, and averages about two miles in width. It lies nearly parallel with the east shore of the bay, the upper extremity approaching within half a mile of the latter. From the east side of Torch lake we pass into Clam lake, a narrow strip of water stretching eastward into Grass lake. From the latter we proceed through a series of small lakes extending northward about twelve miles, and called collectively Intermediate lake. The upper extremity of this lake is but two miles from the south arm of Pine lake, lying mostly in Emmet county and discharging through Pine river into lake Michigan.

The remarkable series of lakes just described is navigable for tugs and small vessels from the East Arm of the bay to the head of Grass lake, making a total length of navigable inland water amounting to eighty miles. Pine lake affords about forty-two miles of inland navigation.

Carp lake in Leelanaw county affords a stretch of inland navigation for tugs, amounting to thirty miles. The outlet of this lake is through Carp river. It extends nearly north and south with a mean width of nearly a mile—taking no account of "the narrows," where, for the distance of two miles the mean width is less than a quarter of a mile.

Glen lake in the same county, lies within one mile of lake Michigan with which it connects through Crystal creek. This body of water covers about one sixth of a township. It is over 200 feet deep—a depth of 15 feet being reached at the distance of ten rods from the shore. It is therefore navigable for ves-

sels of large size, though none above twenty tons burden could approach through Crystal creek; and even this would necessitate some improvements.

Platte lake in Benzie county is similarly circumstanced, though smaller, and lying somewhat further from lake Michigan.

Lake aux Bees Scies (or lake "Betsie")—sometimes called Crystal lake—is the second in size of the lakes of this region. Its western extremity approaches within half a mile of lake Michigan, but its outlet is through the Bees Scies river and Frankfort harbor. The latter is a beautiful little lake reaching to within a few rods of lake Michigan with which it connects through the Bees Scies river. The improvements in progress here will render this harbor accessible from lake Michigan for any vessels which navigate the lake, and it will be absolutely secure from storms from any quarter of the compass. This harbor is two miles long and from a quarter to a half a mile in width.

Numerous smaller lakes of less importance dot the entire region, of which Petobego lake in the northeastern part, and Silver, Long, Bass and Green lakes in the western part of Grand Traverse county are beautiful sheets of limpid water with hard shores. Boardman's lake, within half a mile of Traverse City, is destined, in time, to afford a large accession to the sources of pleasure to the future population of that place. Lime and Bass lakes in the western part of Leelanaw county, Cedar lake in the southeastern part, and Leg lake in the northern part are among the smaller bodies of water with which the region is supplied.

These numerous lakes are filled with pure and palatable water; their shores are dry, and in connection with the surrounding scenery, they constitute, in addition to the facilities they afford for internal communication, the completion of the charms of a series of the most charming landscapes.

The streams of the region are naturally of inconsiderable magnitude. The Manistee river flows through the southeastern portion of Kalkasca county, and passes beyond the limits of the present notice. Boardman's river rises in the

northern part of Kalkasca county, and, after flowing southwest about thirty miles, bends northward and flows about nine miles into the West Arm of Grand Traverse bay. Elk river, the outlet of Elk lake, is scarcely a quarter of a mile long. It discharges a large body of water, and has a sufficient fall to afford a first class water power. The river has been dammed by which the approach from the bay is cut off, while the depth of water in the chain of lakes lying towards the interior is proportionally improved for the purpose of navigation. Carp river, the outlet of Carp lake discharges a body of water nearly as large, and having a fall of five or six feet affords another admirable water power. Here also is a dam. This river is not over half a miie in length. Crystal creek, the outlet o Glen lake, is of smaller dimentions, pursuing a tortuous course of about three miles, and affording by its fall one or two good water powers. The Bees Scies river rises in a chain of lakes in the western part of Grand Traverse county, flows southwest about twelve miles, then north and west about eighteen miles to Frankfort harbor, through which it empties into lake Michigan. This stream affords a water power which is improved near Benzonia.

The Manistee, Boardman and Bees Scies rivers afford good mill sites in the unsettled regions through which their upper waters flow; while numbers of smaller streams have been employed or may be, for driving mills to accommodate their immediate neighborhoods.

The streams of this region are supplied with pure clear water and flow with a lively current over pebbly bottoms to their places of discharge. There are very few instances o water colored by vegetable or peaty accumulations, or stagnated by flats, in the vicinity of the mouths of the streams.

Small brooks and rills are very numerous throughout nearly all parts of the region, so that there is scarcely a quarter section of land that is not supplied with living water, or that has not access to some of the numerous lakes with which the country is so abundantly supplied.

It will at once be noticed that this region is favored with an extent of navigable water which is quite remarkable. Not

only is the whole extent of shore line of lake Michigan and the bay accessible for vessels of large draft, but to augment this shore line to a still greater extent, the bay is parted longitudinally for the distance of seventeen miles, and nearly the entire coast of the lake and bay is diversified by alternate "points" and indentations, which materially increase the means of access to the land. The whole extent of coast line bordering on lake Michigan is not less than seventy-five miles, of which fifty lie within Leelanaw county. Grand Traverse bay presents a coast line of 113 miles, of which 41 lie within Leelanaw county, 50 in Grand Traverse, and 23 in Antrim county.

The shore line of navigable water afforded by the various inland lakes is as follows: In Leelanaw county Carp lake affords about 36 miles and Glen lake about 14. In Benzie county Crystal lake affords about 20 miles and Frankfort harbor about 5 miles. In Antrim county and extending into Grand Traverse, Elk lake affords about 23 miles, Round lake 7 miles, Torch lake 36 miles, Clam and Grass lakes 17 miles. Omitting mention of the considerable lakes in the western part of Grand Traverse county we thus have in this region 158 miles of shore line bordering on the navigable inland lakes, and 189 miles bordering on the bay and lake Michigan. This gives a total of 347 miles of shore line bordering on navigable waters in the region under consideration, and distributed as follows:

In Leelanaw county	141	miles
In Benzie county	50	"
In Grand Traverse county	63	"
In Antrim county	93	"
Total	347	"

IV. TOPOGRAPHY.

The mean elevation of the Grand Traverse region above lake Michigan may be estimated at 230 feet, or 808 feet above the level of the sea. The mean elevation of the lower Peninsula of Michigan is estimated by Higgins to be 160 feet above lake Michigan or 738 feet above the sea level.

The surface of the Grand Traverse region is thus seen to be somewhat elevated. Its configuration is undulating or broken. The drainage is almost perfect, so that swamps and stagnant waters are rarely encountered. The region on the west side of the bay is more uneven than that on the east. An elevated and somewhat broken tract extends from Lighthouse Point through Leelanaw and Benzie counties to beyond Frankfort. Back from this belt the country is equally elevated but less broken. Grand Traverse county is quite diversified with valleys, slopes and plateaux, but the surface rarely sinks so low or becomes so level as to interfere with complete drainage. The surface of Antrim county is undulating, sometimes hilly, and, though well watered, no marshes of importance occur.

Some parts of Leelanaw county present hills of somewhat formidable magnitude. Most of the northern part of the triangle is decidedly rough. The ridge of land separating Carp lake from Sutton's bay attains an elevation of nearly 400 feet above the bay. The slopes, however, are passable for loaded wagons. Carp lake is a beautiful sheet of pure water, resting in the bosom of the hills, which, with their rounded forest-covered forms, furnish it a setting of surpassing loveliness. Except for a short space on the east side, south of the narrows, the shores of the lake are occupied by dry and arable land. The region between Glen Arbor and Traverse City is substantially an undulating plateau lying at an elevation of about 300 feet above the lake. Glen lake is surrounded by hills, which attain an elevation of 250 to 400 feet. North Unity is a bold bluff of clay and sand, formed by the wasting of the lakeward side of a prominent hill by the action of the waves. Sleeping Bear Point is an enormous pile of gravel, sand and clay, which has been worn away on its exposed borders till the lakeward face presents a precipitous slope rising from the waters to an elevation of 500 feet, and forming with the horizon an angle of fifty degrees. Back from the face of the bluff is an undulating plateau of clay, pebbles and sand, covering an area of six or eight square miles, over which the only signs of vegetation are a few tufts of brown, coarse grass with scattered clumps of dwarfed and gnarly specimens of the balm of Gilead—a min-

iature desert, lying 380 feet above the lake. Across this waste of sand and clay the wind sweeps almost incessantly, —sometimes with relentless fury—driving pebbles and sand into the shelter of the neighboring forest, and causing the stunted poplars to shrink away in terror at its violence. The pelting sand has polished the exposed surfaces of the larger fragments of rocks to such an extent that they reflect the sunlight like a mirror. Their surfaces are sometimes worked into furrows, pits and grotesque inequalities in consequence of the unequal hardness of different portions of the stone. The "Bear" proper is an isolated mound rising a hundred feet above this desolate plateau and singularly covered with evergreens and other trees, presenting from the lake the dark appearance which suggested to the early navigators the idea of a bear in repose.

Empire bluff, six miles further south, presents a section of another hill which attains an altitude of nearly 400 feet, and the hills at Point Becs Scies reach an elevation but little less.

Seen from the lake, the natural cuts presented between Cathead Point and Carp river, at North Unity, Sleeping Bear and Point Becs Scies look like huge accumulations of blown sand, and convey the impression of a sterile and inhospitable coast, which is quite at varianee with the indications of the country a a quarter or half a mile back from the shore.

The region about the head of Grand Traverse bay is mostly a level sandy plain, sufficiently elevated for drainage, but on the west and southwest of the head of the West Arm the country rises rapidly by one or two ascents into hills attaining an elevation of 300 or 400 feet. This elevation of the country is maintained most of the way to the Manistee river. The Monroe settlement lies in an elevated undulating expanse reaching south and east for six or eight miles. Toward the west of this the surface subsides, but remains dry to the head waters of the Becs Scies river.

The Peninsula is a gently hilly tongue of farming land. Similar features belong to the eastern shore of the east bay. Indeed, nearly the whole of the western part of Antrim county is made up of plains and gentle slopes, which sometimes reach

an elevation of 200 feet, but toward the interior are ridges which attain a more considerable altitude.

The strictly low lands of the Grand Traverse region are scarcely worthy of mention. Occasionally a narrow belt of swamp borders a lake for a short distance, or spreads out in the vicinity of the mouth of a stream. Some low ground is observed about the head of the West Arm, and more about the head of the East Arm. The immediate vicinity of the upper waters of the Boardman river is somewhat marshy, as also some patches in the southeastern, middle and western parts of Grand Traverse county. The same may be said of the region about the head waters of the Becs Scies river, in Benzie county, as also the vicinity of Cedar river in Leelanaw. Some low ground occurs again about the south end of Elk and Round lakes, and on the borders of the streams in the interior and eastern parts of Antrim county.

Though the immediate shore, as seen from the lake, presents the appearance of a dune covered coast, we find very little sand blown toward the interior, except on the Sleeping Bear. Indeed, the beds of white material forming so striking a spectacle seen from the lake are more clay than sand; and I am not aware of any real dunes except in the region already indicated. The northern lakeward slope of Sleeping Bear Point consists of drifts of shining sand for a distance of two or three miles. The mound which constitutes "the Bear" is also clothed with drifted sand, though the vegetation growing upon it is evidence of a more coherent material beneath.

The scenery of the Grand Traverse region is subdued and soft—sometimes picturesque, always beautiful, in some instances exquisitely so. Viewed from some suitable eminence the landscape presents an undulating sea of verdure, one softly-rounded hill top succeeding another in the retreating view, the dimness of distance lending an ever increasing enchantment to the prospect. Frequently the introduction of water into the landscape gives it almost the perfection of enchantment. From the bluff on which the seminary of New Mission is situated the beholder has an exquisite view of Grand Traverse bay with its eastern and western arms dissolving in

smoke in the dim distance, and the broad lake seen through the mouth of the bay sinking beneath the northern horizon. An emerald fringe of forest skirts the opposite shore; the softened outlines of the Peninsula emerge from the misty embrace of the two arms of the bay, and all around the framework of this scene loom from the background the purple hill-tops, looking perpetually down upon the picture.

From the foot of Pine lake a scene of surpassing loveliness presents itself. We land, perhaps, upon the wharf at the mouth of Pine river. Before us is a sandy slope on the top of which we discover the usual features of a new settlement. Beyond is the forest. It is a pleasant October morning, however, and we follow the well-beaten road through the fresh clearings which stretch out for two miles inland. We emerge from a screen of forest trees and find ourselves standing upon an elevated bluff overlooking as lovely a sheet of water as the sun ever shone upon. You feel almost a transport of delight in emerging so suddenly from the depths of the habitual forest into a prospect so vast, so gentle in its features, so delicate in its tints, and so glowing in the bright sunshine of a fair October morning. Far away to the southeast, for fifteen miles, stretches the placid smiling surface of the water, its white and pebbly shore chasing the contour of the hills in all its meandering sinuosities. The verdant ridges rise on every side from the shining shore line, and hold the lake in their enchanted embrace, while rounded hill-tops bubble up in rapid succession across the retiring landscape till hill and vale and sky, and green and purple and blue dissolve together in the blended hues of the distant horizon.

To one more of these views I cannot resist the temptation to allude. From an eminence about 400 feet high, two or three miles inland from Glen Arbor, on the northeast side of Glen lake, can be seen one of the most beautiful and varied landscapes to be witnessed in any countrv, and one which is well worthy the pencil of the artist. The view is toward the west, and it should be taken when the sky is clear and the atmosphere is pervaded by that softened haze which fuses the sharper angles of the landscape and throws over it a thin veil of in-

scrutable vagueness. From our hill summit we look down on the tops of the trees which cover the plain immediately fronting us. On the left is a portion of Glen lake, its nearer shore concealed by the forest, and the remoter one exposing a white and pebbly margin from which the verdant hills beyond rise hundreds of feet above the watery mirror in which their forms are so clearly fashioned. In front of us the green hills separate Glen lake from lake Michigan, and conceal from view the desert sand-fields of Sleeping Bear. Not completely, however, for the naked and glistening flanks of the northern slope stretch out to view beyond the forest-covered ridge, and embrace the placid harbor which struggles through the intercepting foliage, and blends with the boundless expanse of the great lake still beyond. Farther off in the midst of the water, rises the green outline of the South Manitou island, bearing on its head a glistening cap of sand. Still farther to the right rises the form of the North Manitou, which seems trying to hide itself behind the towering bluff of North Unity that guards the entrance to the harbor from the north. Two little lakes nestle in the rich woodland that spreads its verdure between us and the harbor, screening themselves like wood nymphs behind the thick foliage which half conceals their charms. It is doubtful whether a scene superior to this exists in the country.

V. SOIL.

The arenaceous element of the soil is generally strongly marked. At the same time the region on the west side of the bay is somewhat more sandy than that on the east. The soil of Grand Traverse and Benzie counties is more diversified. Nevertheless, patches of clayey soil are not unfrequent in Leelanaw county, and a well-mixed sandy loam is the dominant character of the soil on the hills. It seems, at first thought, somewhat surprising that the soil of the valleys should be less coherent than that on the slopes and summits of the hills. This disposition, however, is the natural result of the wasting of the hills by storms. These have worn away the more arenaceous materials and transported them to the lower levels, until the

denudation of the hill summits has reached the beds of argillaceous materials with which all the hills of the region are intersected.

A considerable area about the head of the two arms of the bay is a sandy plain, the most of it sufficiently elevated for drainage. On the west of the bay the broken land reaches to the waters edge. On the south it is reached within two miles when a fine belt of adhesive loam extends for about five miles. This is succeeded by two or three miles of clayey soil less perfectly drained, after which we ascend to the beautiful plateau on which the Monroe settlement stands, clothed with a light loamy soil which extends southward with varying accessions of sandy material as far as the Manistee river. Eastward from the Monroe settlement the character of the soil continues to be a light loam, while toward the west and northwest it becomes more sandy and less perfectly drained. On the East of Silver lake is a region in which the argillaceous element decidedly predominates; while the country between New Sweden and Elk lake is favored with a well-drained calcareous loam, equal in fertility to any in the Grand Traverse region, and, from its having been longest settled, generally reputed to be somewhat superior to most parts of the country. This opinion, however, is an unwarranted disparagement of the country in general.

The soil on the east of Grand Traverse bay is a sandy calcareous loam of considerable uniformity, but yet, as on the west side, more sandy in the valleys than on the hill-tops. Benzie county presents diversities of soil similar to those of Grand Traverse county. The western border approximates Leelanaw county in its topography and soil. The southeastern part presents a continuation of the low sandy belt of the adjoining county.

In productiveness the soil of the Grand Traverse region is literally unsurpassed. The evidences of this will be seen when I come to treat of its farm crops and fruits. The proof of it is seen also in the astonishing magnitude of the forest tree which sustain themselves not merely upon the mould which has accumulated upon the surface, but strike their roots deep and

draw up stores of vegetable nutriment from the subsoil. The cause of the fertility of these soils is also apparent. Even the most sandy soil of Leelanaw county is unlike the sandy soils of other regions in its constitution. These sands have not been produced by the disintegration of sandstone strata, as is generally the case with sandy soils. There are no sandstone formations within the limits of the region. They are derived from the disintegration and decomposition of slightly arenaceous limestones. Pebbles of limestone are consequently more or less abundant in the soil—their abundance depending upon the proximity of the undisturbed formation. The continual solution of the calcareous matter of these limestone fragments furnishes a never-failing supply of lime to the soil, at the same time that it disengages additional amounts of sandy particles from their confinement in the limestone mass. These soils, therefore are naturally charged with the fertilizing constituent of plaster, which is lime—though it is probable that the sulphuric acid of common plaster exerts also some agency of which lime is incapable—and even this agency is supplied by the decomposing pyrites which the underlying rocks contribute to the soils of the region.

Aside from their habitual destitution of fertilizing constituents, arenaceous soils possess physical qualities favorable to productiveness. A sandy soil is always light. Atmospheric influences are allowed free access to the roots of vegetation, and to the soil constituents which need to be oxygenated for the purposes of agricultural utility. Even the tramping of men and animals fails to solidify them to the same extent as a clayey or even a loamy soil. A sandy soil is, besides, exempt from supersaturation with water; and yet it holds tenaciously water enough to answer the demands of vegetation. Through the free access of the atmosphere this water rapidly evaporates, thus surrounding the vegetable with vapor and affording the growing leaf the conditions most favorable to its health and expansion. Finally, a sandy soil is proved, by direct experiment, as well as by its promptness in bringing forward a crop, to be a more powerful absorbent of heat than a clayey soil, as well as slower to part with it. The sand is warm much

sooner than the atmosphere and retains its warmth after the atmosphere has received its evening chill. Objection has been made to sandy soils, that their fertilizing constituents "leach out." Let us see. It is evident that whatever sinks into the earth, must go *in a state of solution.* No material particles can be supposed to descend, for we employ this very sand, in filters, to free water from its turbidity and sediments. Experiment proves that clean sand will even abstract some of the saltness from brine. But if the nutritive elements of the soil disappear in a state of solution in the water, there exists a union between them and the water which cannot be materially affected, under the actual conditions, until the water is again evaporated. In a period of dry weather, therefore, when sandy soils draw up by capillary attraction a supply of water from beneath, the same fertilizing constituents must return with it to the surface. Here the water, undergoing a rapid evaporation, deposits again the soluble ingredients which it had carried down at the time of the last rains. Thus it appears how nature has provided for the permanence of the fertilizing elements of the soil, and how drouths are a part of the agency employed by nature in preserving from waste the provision which she has made for the perennial nourishment of vegetation.

It appears, then, that the physical properties of sandy soils tend greatly to favor the development of vegetation, while, aside from the tendency to wash, it is only a deficiency in certain chemical constituents which has given sandy soils in general a bad reputation for being rapidly exhausted of their fertility. It is apparent, nevertheless, that sandy soils may exist not affected by such deficiency, and whose origin has been such that an adequate proportion of alkaline constituents has been supplied contemporaneously with the sand, and must continue to be supplied. The sandy soils of the Grand Traverse region are of this class. They possess, then, all the eminent recommendations dependent on the physical constitution of such soils, and all the chemical constituents which belong to strictly argillaceous or calcareous soils. Hence the secret of the enor-

mous timber growth of the region, and its surprising agricultural productiveness.

Lest it should be objected that sandy soils, unsuited for farming purposes, do sometimes (though rarely, I think,) produce pines and hemlock of a large size, it may be well to remind the reader that the Coniferæ—embracing the pines, hemlock, cedars, firs and spruces—incorporate a large proportion of silicious matter in their constitution, and will flourish well on a soil more purely silicious than other (or gymnospermous) trees. Every one knows that the ashes of the Coniferæ are less desirable for potash manufacture than the ashes of the elm, ash, basswood, maple and beech. It is also notorious that a heavy forest of the latter class publishes a favorable account of the soil upon which they have been nourished.

VI. CLIMATE.

The climate of a region sustains a causal relation to its salubrity, its accessibility, and the character of its vegetable and animal productions. It is one of the most important considerations bearing upon its eligibility for business, settlement and homesteads. Climate depends principally upon three conditions—latitude, altitude above the sea, and relation to large bodies of land and water. The Grand Traverse region lies in about the same latitude as Nova Scotia, the middle of Maine, northern Vermont and New York, St. Paul in Minnesota, and Oregon City, Oregon. Its mean elevation above the sea being 800 feet, its mean temperature should be about two and one-third degrees lower than that of other places in the same latitude lying at the sea level. Or, since a mean annual difference of two and one-third degrees answers, in the temperate zone, to a difference of latitude of one degree and twenty-four minutes, the mean temperature of the year in the Grand Traverse region, in the mean latitude of 44^0 52′, should agreee with other places at the level of the sea in latitude 43^0 28′, which is about the latitude of Portland, Maine, Lockport, N. Y., and Milwaukie and Prairie du Chien, Wis.

I have had access to thermometrical observations, more or less complete taken at Traverse City (latitude 44° 46′) by J. F. Grant, Esq.; at Northport (latitude 45° 08′) by Rev. George N. Smith, and at Grand Traverse (latitude 44° 57′) by Dr. H. R. Schetterly. An abstract of observations taken at Traverse City for six successive winters is given below:

Table I. Abstract of Meteorological Observations at Traverse City.

	HIGHEST.			LOWEST.			MEANS.			
	7am	1pm	7pm	7am	1pm	7pm	7am	1pm*	7pm	Day
1859–60.										
Dec.† ...	35	37	38	–6	9	8	17	24	20	20
Jan.....	46	52	45	–5	7	–7	19	30	22	24
Feb. ...	42	49	45	–14	10	0	16	28	21	22
March..	48	64	63	13	19	21	29	41	34	35
Winter .	48	64	63	–14	7	–7	20	31	24	25
1860–1.										
Dec.† ...	35	37	35	–2	13	12	17	24	21	21
Jan.....	31	36	33	–11	10	1	17	24	20	20
Feb. ...	44	59	44	–10	–12	–13	21	29	25	25
March‡.	40	50	42	–8	–2	–6	21	30	23	25
Winter .	44	59	44	–11	–12	–13	19	27	22	23
1861–2										
Dec.....	58	58	55	12	16	14	29	37	32	33
Jan.....	32	39	34	–9	–6	–1	14	25	20	20
Feb	34	44	33	–15	5	1	14	25	19	19
March..	36	44	46	9	14	17	25	36	31	31
Winter .	58	58	55	–15	5	–1	20	33	25	26
1862–3										
Dec	42	50	50	2	14	14	27	34	30	30
Jan.....	47	50	46	7	8	10	27	33	30	30
Feb	34	49	47	–10	8	3	18	29	24	24
March..	38	46	40	15	19	9	25	32	27	28
Winter .	47	46	50	–10	8	3	25	32	28	28
1863–4										
Dec.....	37	44	44	–2	21	10	24	31	27	27
Jan	34	45	39	–14	–4	–12	18	26	22	22
Feb	37	45	41	–14	–2	–9	22	29	24	25
March..	39	54	44	–10	10	1	21	33	25	26
Winter .	39	54	44	–14	–4	–12	21	30	24	25
1864–5										
Dec	40	46	37	–1	7	6	21	27	23	24
Jan.....	33	38	33	1	11	5	18	25	20	21
Feb	33	45	42	–6	5	–4	18	31	23	24
March..										
Winter .										
Five Winters	58	64	63	–15	–12	–13	21.0	30.6	24.6	25.4

*Observations were taken at noon during the winter of 1859–60.
†Observations began December 8th, 1859, and December 12th, 1860.
‡Ending with the 25th.

Table II. Comparison of Temperatures of the four Coldest Months at Various Places.

PLACES.	DECEMBER.				JANUARY.				FEBRUARY.				MARCH.			
	Mean max.	Mean min.	Extr. min.	Me'n tem.	Mean max.	Mean min.	Extr min.	Mean tem.	Mean max.	Mean min.	Extr min.	Mean tem.	Mean max.	Mean min.	Extr min.	Mean temp.
Traverse City.......	45.50	0.5	-6	25.67	43.33	-5.55	-14	22.83	48.50	-12.0	-15	23.16	52.0	2.6	-10	29.00
Manitowoc, Wis....	44.60	-3.6	-16	24.53	43.50	-10.75	-22	20.66	49.75	-9.0	-16	23.69	57.2	-0.4	-4	32.02
Hazlewood, Min....	38.50	-15.0	-28	13.09	38.80	-24.20	-32	7.20	45.83	-21.0	-28	12.60	50.8	-4.5	-15	27.11
Jt. Johnsbury, Vt...	42.75	-23.0	-34	17.43	43.50	-23.00	-40	17.75	45.00	-26.7	-31	13.71	51.4	-14.8	-27	26.83
Gardiner, Me.......	43.25	-13.0	-25	20.35	40.60	-22.80	-32	17.50	45.60	-11.0	-18	18.68	49.8	-6.2	-10	29.28
Montreal, C. E.....	43.42	-14.62	-32	18.55	39.87	-22.00	-30	12.00	45.12	-20.5	-37	17.08	51.0	-4.7	-11	27.04
Portland, Or.......	57.00	22.0	22	41.51	52.00	20.00	20	38.11	54.00	28.0	28	39.86	58.0	32.0	22	42.47
Ann Arbor, Mich...	48.50	-0.65	-9	24.48	45.00	-11.00	-24	19.73	42.60	-12.0	-14	19.25	52.0	2.7	-10	29.60
Janesville, Wis.....	47.00	-8.26	-20	22.94	43.00	-22.50	-29	11.50	44.60	-16.6	-24	18.96	57.2	-0.8	-6	28.84
Dubuque, Io........	48.40	-3.2	-16	24.28	47.20	-8.60	-20	20.80	46.60	-12.8	-20	21.33	62.4	9.2	1	35.65

Before proceeding to discuss the foregoing table it will be proper to present another one furnishing certain additional information in reference to the localities embraced in Table II. In order that comparisons of temperature instituted amongst different places may convey correct ideas, such comparisons ought to be made between corresponding years, and for long periods of time. Where the number of years embraced is few, and one of them happens to have been unusually mild or unusually severe, the effect upon the means is considerable. The periods of the observations upon which the results of Table II. were calculated are therefore given in the 4th column of Table III.

As altitude is also an important element in such comparisons, the altitudes of the places are given, as far as known, in the 3d column of Table III.

The latitudes of the same localities are given in the 2d column of Table III. The first seven places, it will be seen, are not far removed from the latitude of Traverse City. The remaining localities have been introduced into the discussion for the purpose of showing that places much further south possess a winter climate more severe than that of Traverse City.

Table III. Supplementary to Table II.

PLACES.	LATITUDE.	ALTITUDE AB'VE SEA LEV.	PERIOD OF OBSER.
Traverse City	44° 45′	525 ft.	1859–65
Manitowac	44° 07′		1856–9
Hazlewood	45° 00′		1954–9
St. Johnsbury	44° 25′	540 ft.	1854–9
Gardiner	44° 11′	75 ft.	1855–9
Montreal	45° 30′	118 ft.	1855–64
Portland	45° 24′	150 ft.	1859
Ann Arbor	42° 16′	891 ft.	1854–7
Janesville	42° 42′	768 ft.	1854–9
Dubuque	42° 30′	680 ft.	1854–9

The second and third columns of Table II. show for each place the mean of the December *maxima* and *minima* during the years covered by the observations—that is the mean of all the highest December observations for the several years, and

the same of the lowest. The fourth column shows the lowest degree reached by the thermometer in December, during the whole period of observations for each place. The fifth column exhibits for each place the mean temperature of all the Decembers embraced in the period of the observations. The remaining columns of the Table give the same results for the months of January, February and March.

Of the localities lying nearly on the parallel of Traverse City, it will be observed that Manitowoc is located immediately on the western shore of Lake Michigan, and has Green Bay lying not over 35 miles to the north. It necessarily experiences therefore some modification of its winter climate from the influence of those large bodies of water. In this respect it seems even to be more favored than Milwaukie, 75 miles further south, which has colder winters—the difference, perhaps, being the measure of the influence of Green Bay upon the winter climate of Manitowoc. Portland, Oregon, is under the influence of the Pacific ocean, as the observations show. Hazlewood, Min., Montreal and St. Johnsbury are situated inland, and may be taken as fairly representing the continental temperature on their parallels, as unmodified by large bodies of water.

The adaptation of a winter climate to the safe wintering of fruit trees and farming crops is not indicated by the mean temperature of the winter, nor by the mean temperature of the several months. Nevertheless, when this comparison is made, we perceive that the climate of Traverse City is milder than that of any other locality given in the table—Portland, Oregon, of course, excepted. In the month of December Manitowoc is over one degree colder; Hazlewood, $12\frac{1}{2}°$; St. Johnsbury, $8\frac{1}{3}°$; Gardiner, $5\frac{1}{4}°$; Montreal, 7°; Ann Arbor, $1\frac{1}{4}°$; Janesville, $2\frac{3}{4}°$; Dubuque, 1°.

In the month of January Manitowoc is $2\frac{1}{4}°$ colder than Traverse City; Hazlewood, $15\frac{2}{3}°$ colder; St. Johnsbury, 5°; Gardiner, $5\frac{1}{3}°$; Montreal, $10\frac{3}{4}°$; Ann Arbor, 3°; Janesville, $11\frac{1}{3}°$; Dubuque, 2°.

In the month of February Manitowoc is half a degree warmer than Traverse City; Hazlewood, $10\frac{1}{2}°$ colder; St. Johns-

bury, $9\frac{1}{2}$°; Gardiner, $4\frac{1}{2}$°; Montreal, 6°; Ann Arbor, 4°; Janesville, 4°; Dubuque, 2°.

In the month of March the mean of the more southern localities begins to feel the influence of occasional warm southerly and southwesterly winds, while Traverse City is still environed by the winter temperatures imprisoned in the ice of the bay.

It is the extremes of winter temperature which produce such frequent destruction of the more delicate varieties of fruit trees. The table furnishes the mean *minima* of the several places for the cold months of the year. In December the mean *minimum* of Manitowoc is 4° lower than at Traverse City; of Hazlewood, $15\frac{1}{2}$° lower; of St. Johnsbury, $23\frac{1}{2}$°; of Gardiner, $13\frac{1}{2}$°; of Montreal, 15°; of Ann Arbor, 1°; of Janesville, $8\frac{3}{4}$°; of Dubuque, $3\frac{3}{4}$°.

In January the mean *minimum* of Manitowoc is $5\frac{1}{4}$° below that of Traverse City; of Hazlewood, $18\frac{1}{2}$°; of St. Johnsbury, $17\frac{1}{2}$°; of Gardiner, $17\frac{1}{4}$°; of Montreal, $16\frac{1}{4}$°; of Ann Arbor, $5\frac{1}{2}$°; of Janesville, 17°; of Dubuque, 3°.

In February the mean *minimum* of Manitowoc for the years compared is 3° higher higher than at Traverse City; of Hazlewood, 9° lower; of St. Johnsbury, $14\frac{3}{4}$° lower; of Gardiner, 1° higher; of Montreal, $8\frac{1}{2}$° lower; of Ann Arbor, the same; of Janesville, $12\frac{1}{2}$° lower; of Dubuque, $\frac{5}{8}$° lower.

The mean *minimum* for March is lower for every one of the places compared with Traverse City, except Portland, Oregon.

The favorable character of the winter climate of Traverse City is placed in a still stronger light if we compare the *extreme minima* for a series of years. The mean *minimum* may be of moderate severity, while on one or two occasions in the course of the winter, or still more likely within a range of five or six years, the mercury may sink to the damaging limit. The *extreme minimum* of Manitowoc compared with that of Traverse City is seen to be, in the month of December, 10° lower; of Hazlewood, 22°; of St. Johnsbury, 28°; of Gardiner, 19°; of Montreal, 26°; of Ann Arbor, 3°; of Janesville, 14°; of Dubuque, 10°.

In January. the *extreme minimum* of Manitowoc is 8° lower than at Traverse City; of Hazlewood, 18°; of St. Johnsbury, 26°; of Gardiner, 18°; of Montreal, 16°; of Ann Arbor, 10°; of Janesville, 15°; of Dubuque, 6°.

In February, the *extreme minimum* of Manitowoc is 1° lower than of Traverse City; of Hazlewood, 18°; of St. Johnsbury, 16°; of Gardiner, 3°; of Montreal, 22°; of Ann Arbor, 1° higher; of Janesville, 9° lower; of Dubuque, 5° lower.

It thus appears that under every point of view the winter climate of Traverse City is materially milder than that of other places in the same latitude either east or west. It is materially milder than that of places two and a half degrees further south. The *minimum* range of the thermometer being but 15° below zero, it does not reach the point at which peach trees are injured; and in this respect the winter climate compares favorably with that of middle Ohio, Indiana and Illinois. Indeed, the winter extremes for ten years past, during which peach trees have been growing in the Grand Traverse region, have been less than at Cincinnati or St. Louis, or even Memphis, in Tennessee. During the memorable "cold spell" of New Year's 1864, the thermometer is reported to have sunk at Milwaukie and Janesville, Wis. to 40° below zero; at Chicago, to 29° below; at Kalamazoo, Mich., to 20° below; at St. Louis, to 24° below; and at Memphis, Tenn., to 16° below. The following figures exhibit the movement of the mercury at Northport and Traverse City during the same interval:

Table IV. Observations during the cold cycle of 1863-4.

	NORTHPORT.			TRAVERSE CITY.		
1863-4.	7 A. M.	2 P. M.	10 P. M.	7 A. M.	1 P. M.	7 P. M.
Dec. 31.	22	28	18	20	29	28
Jan. 1.	0	-8	-14	3	-2	-12
„ 2.	-14	-6	-3	-14	-4	-3
„ 3.	-3	2	8	3	10	3
„ 4.	4	11	7½	1	17	8
„ 5.	11	16	8	8	19	12

This cycle of cold weather, which extended over the entire northwest and destroyed or damaged fruit trees in every

northwestern State, caused no damage whatever in the Grand Traverse region.

Another characteristic of the winter of this region is its comparative uniformity of temperature. The mercury neither rises as high nor sinks as low as in other regions along the same parallel of latitude.

Other comparisons are no less surprising than those which have just been made. Autumnal frosts are postponed to a remarkably late period. Unlike other regions, frost seldom appears till the mercury actually reaches 32°. The first killing frosts ordinarily occur throughout the region, between the middle and end of October. Sometimes they are delayed till late in November. They occur at Traverse City and southward from there somewhat earlier than at Northport, Glen Arbor and Frankfort. The first killing frost this year at Traverse City was a slight one, October 13th, but it did not reach Northport. Tomatoes and other tender vegetables were still growing thriftily at Northport and Pine River, and even at the head of Little Traverse bay, when I visited those places, Oct. 27th and 28th. On the night of the 28th, however, the thermometer sank to the freezing point, and injured vegetation generally throughout the region. On the 5th of November, it froze again. At the same time the mercury sank to 24° at Ann Arbor, and to zero at Bangor, in Maine. Nevertheless, when I left the region on the 8th of November, the leaves of apple and peach trees were still perfectly green, while those of the forest were partially changed and beginning to fall. On reaching the southern part of the State, vegetation presented already the appearance of mid-winter.

Autumnal frosts occur only after days of very threatening severity. I observed that when, during the day, the thermometer rises as high as 40°, it is seldom crowded down to the freezing point the following night. At Ann Arbor we often get frost after the thermometer has been at 60° during the previous day.

Snow falls in November or December, before the ground has been materially frozen, and lies without thawing till the following April. It accumulates to the depth of two or three

feet, and sometimes, in certain localities, to a greater depth. Its disappearance is postponed till abouth the 10th of April, when the danger of severe frost is generally passed. The ground consequently escapes freezing throughout the entire winter, so that root crops may be left out without damage. Potatoes are thus, frequently, wintered in the ground without digging. It always happens that the few remaining in the soil after the crop has been gathered, vegetate in the following spring, and produce a spontaneous crop. Thus they propagate themselves from year to year, so that the Irish potato has become a naturalized weed, growing in corn fields and wheat fields, and sometimes in uncultivated fields, and by the road side. I saw potatoes growing in places where I was informed no seed had been planted for ten years.

The same preservative effects of snow are witnessed in other crops, and in the bulbs, tubers and roots of ornamental plants. The Dahlia blooms till the last of October, and after this the tubers may be left in the soil till the following spring, when, not long after the disappearance of the snow, they send up fresh shoots. Delicate green-house roses stand out with the same impunity as in Alabama and Louisiana. Mrs. Judge Fowler, of Mapleton, on the Peninsula, informed me that she had in her garden forty varieties of delicate roses, which stand out every winter.

Wheat, of course, is never in danger of winter-killing in a region thus exempt from extremes of cold, and thus clothed during the entire winter with a thick mantle of snow.

The presence of snow till the middle of April preserves vegetation from the stimulating influence of occasional warm days, and the buds of fruit trees consequently remain dormant till the danger of severe frost is passed. When the snow finally disappears, the soil is in a condition to receive immediately the genial influence of sunshine and atmospheric action. The disagreeable period of mud caused by the slow escape of frost from the soil is unknown. The breaking up of the ice in the bay exposes the entire region to the equalizing influence of large bodies of water, and the region is thus nearlv as exempt from the destructive effects of late vernal frosts, as from those

of late autumnal ones. No damaging frost is liable to occur later than the middle of May, which is about the period of latest frosts in northern and middle Ohio.

The mean temperatures of the four winter months at Grand Traverse, for five years, are as follows:

December	25°.2
January	23°.2
February	23°.0
March	29°.0

The following are the means of four months of the year 1860 at Northport:

January	22°.48
February	22°.91
March	33°.91
April	40°.33

The temperature of summer is as remarkable for its moderation and uniformity as that of winter. I have not had the opportunity to examine any record of thermometrical observations made during the summer, but the summer climate is admitted to be exempt from extremes and sudden changes. Yet the mean temperature is sufficiently high to mature peaches, tomatoes, tobacco and the like.

The facts which I have disclosed above touching the winter climate of the Grand Traverse region are well calculated to excite surprise; but I think no one can question the figures. A moment's reflection, moreover, will reveal the reason for the peculiarities of the climate of this portion of the State. The Grand Traverse region, like the peninsula of Florida, Sweden and the British islands, is subjected to the equalizing influences of large bodies of water. Lake Michigan borders the whole western slope of the State. In the region under consideration the body of water is greatly augmented by the bay which reaches its two arms thirty-four miles into the interior. Moreover, the triangle forming Leelanaw county is embraced by two large bodies of water, and enjoys a situation unlike that of any other portion of the northwestern States. Our cold winds generally proceed from the southwest or west. Passing over the open water of Lake Michigan sixty miles in width, the temperature of which never sinks below 32°, it is impossible to avoid ab-

stracting a considerable amount of heat, so that when these cold westerly winds strike the Michigan shores of the lake, the severity of the winter gales is materially mitigated. Moreover, the severest and most destructive winter gales proceed from the southwest, and the trend of the lake is such that these winds, on striking the Grand Traverse shore have traveled over more water than southwest winds striking the Michigan shore in Ottawa, Van Buren and St. Joseph counties.

But the thermometer on some occasions sinks to a *minimum* with an easterly or even a southeasterly wind—as in February, 1857, when it sank twenty-four degrees below zero at Ann Arbor with an easterly wind and a cloudy sky. Before such winds the eastern shore of lake Michigan in St. Joseph county and northward experiences no protection from the proximity of a large body of water. In the Grand Traverse region, on the contrary, the diameter of the peninsula is so much diminished that easterly winds retain the softening influence exerted by the waters of lake Huron. Moreover, the whole of Leelanaw county enjoys nearly as complete protection from easterly as from westerly winds. It is almost impossible for a gale from any direction to bring into Leelanaw county a temperature of eighteen or twenty degrees below zero, the point at which the limbs of peach trees are liable to be killed.

No observations on the other elements of climate have been brought under my observation. It is obvious, however, that a region so environed by water must possess an atmosphere of sufficient humidity to offer a guarantee against habitual drouths. I am informed that no severe drouth has ever been experienced before the summer of 1864, when the whole northwest was parched to an unprecedented extent.

VII. SALUBRITY.

A region possessing such a climate, and such physical features as have been described above, can scarcely offer any other than favorable sanitary conditions. Accordingly, I was everywhere assured by the inhabitants of the region that diseases are almost unknown. I heard of a few cases of typhoid fever in the neighborhood of Glen Arbor, and a few cases of dysen-

tery about Leland and in Antrim county. Bilious diseases are foreign to the country. No ague was ever known to be indigenous to the region. On the contrary, many chronic cases of suffering from malarious influence have been relieved and cured by a residence in the region. The uniformity of the temperature and the purity of the air and water are also favorable in pulmonary diseases; and I learned of some rheumatic affections that had been cured by a few months residence.

VIII. TIMBER AND NATIVE PLANTS.

Passing fróm a survey of the physical features of the Grand Traverse region, I proceed to offer a brief account of its natural history. Generally speaking the region is covered by a magnificent growth of hardwood timber. The exceptions to this statement are few and unimportant. By far the most abundant species is the sugar maple (*Acer saccharinum*). This distributed generally throughout the region on both sides of the bay. It bears, however, a larger ratio to the whole forest on the west side. Mingled with this are the beech (*Fagus sylvatica*), white or American elm (*Ulmus Americana*), and hemlock (*Abies Canadensis*). The beech, as might be expected, is more abundant on the more coherent soils of the east side of the bay and in Grand Traverse county. The hemlock is pretty generally scattered through the forest of Leelanaw, Grand Traverse and Benzie counties, forming on an average about one fifteenth, or less, of the forest growth. It occurs less frequently in Antrim county. In certain situations where the soil is most retentive we encounter patches of forest diversified with the black ash (*Fraxinus sambucifolia*), while the arbor vitæ, or western "white cedar" (*Thuja occidentalis*) holds joint possession with the balsam fir (*Abies balsamea*), in some moist and wet lands, and the tamarack (*Larix Americana*) sometimes crowds itself into the company of the other denizens of the occasional swamps. The white pine (*Pinus strobus*) is very partially distributed. Some majestic specimens—individuals of which attain a diameter of nearly five feet—may be seen in the south part of Leelanaw county on the east of Cedar run, where some wasteful settlers are engaged in fell-

ing them in winrows and wickedly burning them. A valuable belt of white pine lies in the southeastern part of Benzie county on the upper waters of the Becs Scies river, and another on the upper waters of Boardman river in Grand Traverse county, whence the logs are floated to Traverse City and worked up in the mill of Hannah, Lay & Co., which, according to the "Statistics of Michigan, 1864," produced in 1863 10,200,000 feet of pine lumber, worth $112,000. The product of the present year is said to be twelve million feet. Another pinery exists in the interior of Antrim county on the tributaries of Grass lake. The logs from here are worked up in the mill of Dexter and Noble at Elk Rapids, which, according to the authority above quoted, produced, in 1863, 4,000,000 feet, valued at $10,000—a valuation which would seem to be erroneous. The product of the present year is probably nine millions of feet. The county of Leelanaw is also reported to have produced in 1863, 395,000 feet of lumber (probably but little of it pine lumber), valued at $91,500.*

Occasionally, as on the Peninsula, I noticed the Norway pine (*Pinus resinosa*) in company with the white pine, sparingly dispersed through the forest.

The oak is not regularly distributed; but in certain regions it constitutes an important feature. I observed the red and white oaks (*Quercus rubra* and *alba*) growing abundantly on the sandy plains about the head of the two arms of Grand Traverse bay. I noticed the red oak growing also at Elk Rapids, and both oaks on the Peninsula. A grove of white oaks interspersed with black oaks, occupying 200 acres, flourishes on the north side of Round lake. I saw them also on the shores of Crystal lake in Grand Traverse county; on the ridges back of Glen lake; between Carp lake and Sutton's bay and in many other places. The trembling aspen or poplar (*Populus grandidentata*) is quite frequent about the borders of clearings—especially on the Peninsula—while the balsam popular (*Pop-*

*These statistics, taken from the work referred to, disclose some curious discrepancies. Following the figures, one dollar buys 4 feet of lumber in Lenawee county, 90 feet at Traverse City, and 400 feet at Elk Rapids.

ulus balsamifera) is also occasionally seen in all parts of the region. I was greatly interested to notice this tree struggling for an existence on the bleak and sterile plateau of the Sleeping Bear Point. Its gnarled and miserably dwarfed condition proclaimed the nature of the conflict it had endured; and a wonder arises why a tree so ill adapted to the situation should attempt to establish itself where nothing else can maintain an existence.

The yellow birch (*Betula excelsa*) is a frequent denizen of the forest, and sometimes grows to an extraordinary size. A specimen seen in Antrim county measured eleven feet and four inches in circumference four feet above the ground. The false white birch (*Betula populifolia*) is also frequently encountered. The black cherry (*Cerasus serotina*) is not unfrequent, and sometimes becomes a troublesome intruder on the borders of clearings. The soft maple (*Acer rubrum*) occurs sparingly about Antrim and probably in other localities.

This primitive forest presents to the eye of the traveller a scene of wonderful majesty, magnificence and interest. The towering hemlocks with their straight cylindrical trunks often three, four, or nearly five feet in diameter expand their crown of dark green spray at the summit, while the majestic maple, beech and elm lift their heads to an equal altitude, and mingle their paler and brighter foliage with that of the sombre evergreen. The undergrowth is scant, consisting of the striped maple (*Acer Pennsylvanicum*) and witch hazel (*Hamamelis Virginica*) with patches of dwarf yew or ground hemlock (*Taxus Canadensis*)—the latter of which is much more abundant on the west side of the bay. The forest is therefore an endless colonnade of majestic pillars; and, but for the prostrate forms of the fallen patriarchs of the wood, a vehicle could be driven through the unbroken forest from one end of the region to the other.

Some of the low grounds in the vicinity of Glen Arbor are covered with the cranberry vine (*Oxycoccus macrocarpus*) and the half shaded borders of the lakes are often clothed with the evergreen bearberry (*Arctostaphylos uva-ursi.* In most half-open situations the blackberry (*Rubus villosus*) and red

raspberry (*Rubus strigosus*) flourish luxuriantly and afford an inexhaustible supply of fruit. The raspberry sometimes produces two crops in the season. I saw at several places, ripe fruit, green fruit and flowers existing together in the latter part of October, upon canes of the current year's growth. The huckleberry (*Gaylussacia resinosa*) is also abundant in the sandy clearings about the head of the bay. The native strawberry of the region is *Fragaria Virginiana*, and it may be seen in fruit from June to October.

A singular and interesting assemblage of trees and shrubs covers the Sleeping Bear proper, and by its dark green foliage strongly isolates this pile of sand from the shining desert around it. The only trees upon the mound, besides some dwarfish balm of Gileads, are the balsm fir and white cedar. A stump of one of the latter, cut by the operators of the Lake Survey, measured two feet in diameter. The shrubs consist of the trailing red cedar (*Juniperus Sabinæ*), choke cherry (*Cerasus Virginiana*), dogwood (*Cornus florida*), snowberry (*Symphoricarpus occidentalis*), bearberry, wild rose, (*Rosa blanda?*) and frost grape (*Vitis cordifolia*). The fruit of the latter, as well as that of the choke cherry was found to be quite palatable, though the leaves of the grape seemed to be uninjured by the frost, as late as the 24th of October. It is quite certain that the southern side of this lofty mound of sand would ripen the Isabella or Catawba grape with complete success.

It will be remarked that the vegetation of the region does not present a northern aspect. The northern white birch (*Betula papyracea*) is wanting, and the fir and spruce are but very feebly represented. The native strawberry is the Virginian species, and the pendent lichens, so marked a feature of the lake shore forest on the opposite side of the Peninsula, in the same latitude, are entirely unknown.

IX. ANIMALS.

It is not intended under this head to attempt an enumeration of all the animals of even a single class; but only to bring

together a few statements of greater or less economical interest. The most conspicuous mammalian quadrupeds are the black bear (*Ursus Americanus*) the Virginian deer (*Cervus Virginianus*), the red fox (*Vulpes fulvus*), the otter (*Lutra Canadensis*) and various squirrels—among wich I noticed the black variety quite frequently. The bear is nearly confined to the remote portions of Benzie, Grand Traverse and Kalkasca counties. Of birds, the ruffed grouse or partridge (*Bonasa umbellus*) is the most important, and affords a valuable article of food. The quail (*Ortyx Virginianus*) has recently been observed in considerable numbers. Of fishes, the usual lake species occur in the bay, but not in such numbers to render fishing a business of much importance. The speckled trout (*Salmo fontinalis*) occurs plentifully in all the streams of the region, and in many of the small lakes. Among insects, the mosquito (*Culex pipiens*) is one of the most conspicuous; but it is worthy of mention that its disappearance for the season occurs as early as July or August. Indeed, the mosquito is much less troublesome in the Grand Traverse region than at Chicago.

Another insect likely to become important from its ravages committed upon vegetation, is the canker worm moth (*Anisopteryx pometaria*), and I think it worth while to present some account of its nature and habits.

In the latter part of May or early in June the young leaves of the maple, elm and some other trees are seen to be infested by myriads of " worms" (so-called), which are the larves of an insect belonging to the tribe of moths. These larves are furnished with legs near the extremities only, and consequently move with a measured motion which has caused them to receive the name of "span worms" or "measure worms." The fullgrown larves attain the length of an inch or more. A great difference of color is observable among the worms of different ages. The young are generally of a blackish or dusky brown color, with a yellowish stripe on each side of the body, which is also whitish on the under side. When fully grown they become paler on the back, and a black line appears above the

yellowish one on the sides. In some a greenish-yellow color prevails; in others, a clay color, with dark lines or spots variously distributed on the sides and back. They commence their depredations by eating small holes in the leaves, which they continue to enlarge till, in some cases, the entire pulp of the leaf disappears, leaving little more than the mid-rib and veins. They attain full growth in June, when about four weeks old, and then begin to quit the trees. Some creep down the trunk; but great numbers let themselves down by their threads from the branches. After reaching the ground, they immediately burrow in the earth to the depth of from two to six inches. Here, by repeatedly turning and fastening the loose particles of earth by a few silken threads, they form little cells, and in twenty-four hours have changed to chrysalids. The chrysalis is about half an inch in length, of a light brown color, largest in the females. In the autum, after the appearance of frosts, the perfect insects begin to make their appearance from the crysalids. They appear at various times when the weather is sufficiently mild, from October to March. I saw countless numbers of the males fluttering over the surface of a light fall of snow, when riding through the woods early in November. I had seen them previously, during a cold rain, in October.

The females of the perfect insect are destitute of wings, and hence do not wander far from their place of birth. The males have a body about an inch and a half in length, and measure about an inch across the wings. The wings are rather large, thin, and covered with a grayish silky down. The hind wings are paler in color than the others. The females, on their appearance, whether in autumn, winter or spring, make their way toward the nearest trees, and creep slowly up their trunks. A few days afterwards the males may be seen fluttering about them, when, after pairing, the females deposit their eggs in clusters of from sixty to one hundred, upon the branches of the trees. The eggs are glued to each other, and to the bark, by a grayish varnish impervious to water. Their task having been accomplished, the insects soon die. About the middle or last of May the eggs are hatched, and a brood of worms appears

upon the young foliage of the forest and fruit trees, which furnish these larves with their appropriate food.

Feeling uncertain whether the canker worm moth of the Grand Traverse region is the same as the common species of New England, I forwarded some specimens to A. S. Packard, Jr., M. D., of the Boston Society of Natural History, who informed me that it is not the common species, but probably another one sparingly distributed over New England, and known by the name of *Anisopteryx pometaria*, Harris.

It is a fact of scientific, as well as agricultural importance, that this species exists in such abundance in a region so isolated and so remote from Boston, which seems to have been the metropolis of the canker worms.

I was informed that this insect caused considerable damage, the past season, to apple orchards in the vicinity of Elk Rapids. As its depredations are likely to increase for some time, instead of diminishing, it will be well to adopt some measures of restraint. These, fortunately, are not difficult or expensive. The most effectual means are based upon the circumstance that the females are wingless, and are hence obliged to crawl up the trunks of the trees to deposit their eggs. Any means which will arrest the progress of the female will protect the tree. The editor of the *American Agriculturist* recommends covering the ground about the base of the tree with ashes. In New England, tar is frequently employed, by smearing a narrow belt around the tree trunk, or by closely girding the tree with a band of clay, paper, tin or cloth that has been covered with tar. In this case, care must be taken that no room is left between the tree and the girdle, through which the insects can ascend. Various other means have been recommended, for information on which the reader may consult Harris' "Insects Injurious to Vegetation," Boston, 1862. It is obvious that whatever preventives are employed, must be resorted to before the chrysalids are changed. There are some reasons for believing this species to come out of the ground, principally in the autum, which is contrary to the habit of the common species (*Anisopteryx vernata*, Harris). The remedies must, therefore, be applied in October and November, and renewed

again whenever the weather becomes mild enough to stimulate the insects to activity.

Our warfare upon them need not cease after the appearance of the "worm" upon the trees in May. They may be destroyed by sprinkling on them finely pulverized quick-lime mixed with ashes, at times when the leaves are wet. Whale oil soap suds sprinkled on them will also kill them, as it does most other insects. These remedies may be employed where the number or size of the trees to be protected is not too great.

X. GEOLOGY.

1. General Geology.—The general geological structure of the Lower Peninsula of Michigan may be learned by reference to my "Report of the Progress of the Survey of Michigan for 1859–60." The Grand Traverse Region, like most parts of the Peninsula, is covered with drift materials of such depth that exposures of the underlying strata are quite rare. In order, therefore to investigate the geology of the region, it is necessary to extend our observations considerably beyond its limits to other regions where the strata underlying this region rise to the surface and present exposures. With this view, my personal examinations on the present survey were begun at the head of Little Traverse bay, extending thence southward into Benzie county. The results embodied in the following pages, however, are drawn, to a large extent, from observations made in all portions of the Peninsula during the continuance of the public geological survey. Confirmations of the conclusions arrived at from the examination of outcrops beyond the limits of this region, have been sought in the soundings of the United States Lake Survey, and in the constituents of the drift materials of different parts of the region.

The information which I have been able to obtain from all sources shows that the strata underlying the northwestern slope of the Lower Peninsula of the State have a gentle dip southeastwardly, toward the middle of the Peninsula. This dip of the strata is preserved in traveling northwest across Lake Michigan into the Upper Peninsula, and was undoubtedly communicated to the strata at the time of some eruption

and uplift occurring in the Upper Peninsula—perhaps at the period of the eruption of the trap of Keewenaw Point. We are not aware of the occurrence of any geological disturbances of later date than this eruption; and there are, therefore, some grounds for presuming that the disturbance which tilted the Lake Superior sandstone, tilted also the other strata of the Lower Silurian and even of the Upper Silurian and Devonian systems—extending its effects as far as the Lower Peninsula. Aside, however, from the general dip of the strata within the region under consideration, there are no considerable evidences of disturbance. The rocks along the south shore of Little Traverse bay present a series of broad, wave-like undulations; and, on the east shore of Grand Traverse bay are seen two cases of abrupt dislocation, accompanied by a downthrow of three or four feet.

The following table presents a view of the formations which will be brought under consideration in the present report:

Quaternary System		Lignite. Drift.
Lower Carb. System	Marshall Group.	
Devonian System	Huron Group	Light Shales. Black Shales.
	Hamilton Limestones.	
	Corniferous Limestone.	
Upper Silurian System	Onondaga Salt Group.	

2. Salina Group, or Onondaga Salt Group.—This series of argillaceous limestones, shales, sandstones and gypsum underlies the entire Peninsula, outcropping at the base of Mackinac, Bois Blanc, Round and Little St. Martin's islands, and on the main land west of Mackinac. Passing thence under the Peninsula, it reappears in Monroe county, Michigan, and Sandusky bay, Ohio. On the west of Lake Michigan it outcrops, to a limited extent, near Milwaukie, and on the east, at Galt and that vicinity, in Canada West. It may come to the surface in some portions of the region between Little Traverse bay and the Straits of Mackinac—a region not yet geologically explored. It furnishes the gypsum of the Grand River, in Canada, of Sandusky, Ohio, and of Onondaga county, New York. It abounds in the same deposit at Little Point au

Chene, west of Mackinac. It is also the source of the supply of brine to the salt wells of New York, and to those at St. Clair and Port Austin in this State. It underlies the Grand Traverse region, but the places of outcrop of the formation are far beyond its limits.

3. Corniferous Limestone.—The elevated limestone region south of the Straits to Little Traverse bay belongs to this formation. It thence dips under the Peninsula and reappears in Monroe county and the northern portions of Ohio and Indiana. Its western outcrop is in the bed of lake Michigan, and its eastern is under lake Huron. It is the most conspicuous and important limestone formation in the the Lower Peninsula, affording its principal supply of quicklime, and furnishing in places a building stone of considerable value. It is often saturated to a remarkable extent with petroleum and black bituminous matter, causing it to be generally regarded by the uninformed as an oil producing rock—an error which, in numerous instances, has only been discovered and admitted, after many thousand dollars had been wasted, in contempt of scientific authority. The formation does not outcrop within the limits of the Grand Traverse region as I have defined it.

4. Limestones of the Hamilton Group.—As the present survey has thrown much additional light upon the geology of this formation, I shall proceed to give some account of the rocks belonging to it, at each outcrop within the limits of our region.

Near the head of Little Traverse bay, south of the point—E side sec. 23 T. 35 N. 5 W. (Locality 855 of the Geological Survey) the following section is seen:

Section at 855.

E. Limestone, light, argillo-calcareous, in beds from 1 to 8 inches thick.................................. 4 ft.
D. Limestone, rather thick-bedded, somewhat porous, with an uneven fracture, and containing crystals of calcareous spar.................................. 4 ft.
C. Limestone, thin-bedded, light colored, argillo-calcareous, breaking into small angular fragments, contains corals.................................. 6 ft.
B. Limestone, much broken, in beds from one to two feet thick.................................. 6 ft.

A. Limestone, pale buff, argillaceous, banded, containing fossils .... 2 ft.

The dip at this place is about five degrees toward the southwest.

About twenty rods west of this locality is a more considerable exposure (856) extending along the beach for three-fourths of a mile and forming an escarpment which, at some points attains an elevation of thirty-five feet. The stratification is mostly horizontal, presenting slight undulations within distances of ten or twelve feet. Toward the western part of the exposure the cliff partially subsides. The trend of the coast is about southwest; and when, near the mouth of Bear creek, the trend changes to west, the escarpment strikes inland by continuing toward the southwest. The following succession of strata may be made out at this outcrop:

Section of Stromatopora Beds (856.)

D. Limestone, pale buff, very massive, breaking in regular blocks, somewhat arenaceous, inseparable from the following, except in its structure; contains the same fossils .... 12 ft.

C. Limestone, pale buff, massive, brecciated in places, vesicular; falling down in huge blocks. Becomes more regular westward. It has a rude concretionary structure from the abundance of *Stromatopora* (with large cells) .... 20 ft.

B. Limestone, thin-bedded below, thicker above, broken, with a 10 inch band of dark soil (bituminous) at top and thinner ones below. Contains *Atrypa reticularis*, *Favosites Alpenensis*, &c.... 10 ft.

A. Talus or sloping beach of fragments............. 4 ft.

The *Stromatopora* at this exposure is by far the most abundant fossil, constituting the principal mass of No. C, and rendering it a veritable coral reef. Fine specimens of this coral can be collected in any quantity, even to a shipload. The individual masses are sometimes of an elongate-ovoid form, from two to four feet in length, with the concentric plates arching across the mass. These forms are found both erect and prostrate. At other times they are more spherical, attaining a diameter of four or five feet, and giving the rock or reef a confused concretionary structure. From the abundance of this coral I shall designate the strata in which it abounds as the "Stromatopora Beds."

The stratum No. C embraces also the following fossils: *Atrypa reticularis*, *Merista*, *Spirigera concentrica*, *Zaphrentis*, *Heliophyllum*, *Favosites*, *Cystiphyllum*, *Stromatopora* (smaller cells), *Cladopora*, *Conocardium*, *Tropidoleptus carinatus*, and other species.*

In the fields half a mile back from the bay I picked up *Strophomena nacrea*, *Acervularia Davidsoni*, *Atrypa reticularis* and *Favosites Alpenensis.*

At the saw-mill on Bear Creek, half a mile above its mouth is an outcrop of dark brown, very bituminous limestone, abounding in *Heliophpllum*, *Favosites Alpenensis*, *Atrypa reticularis.* It is clearly the same bed as the dark bituminous limestone about Thunder Bay, where, as well as here, its place seems to be above the Stromatopora Beds.

About a mile southwest from Bear creek we find a considerable exposure of a very different sort of rocks. This is on the S. E. ¼ Sec. 1 T. 34 N. 6 W. (Locality 857). The rocks are seen to have a dip varying from 5 to 15 degrees, and extending along the beach for 360 feet, with a mean dip of about 8 degrees, which would give a thickness of 53 feet to the whole exposure. The following is a statement of the stratification:

Section of Tropidoleptus Beds (857.)

E.	Limestone, argillaceous, sub-crystalline, the thinner layers shaly, terminated by a few inches of black shale	14 ft.
D.	Limestone, very dark chocolate colored, argillaceous, compact, much broken	3 ft.
C.	Limestone, very dark, bituminous, in beds from six inches to one foot thick, shaly or subcrystalline.	12 ft.
B.	Limestone, dark brown, argillaceous, uneven bedded, breaking with a ragged uneven fracture	5 ft.
A.	Limestone, dark, compact, argillo-calcareous, breaking with a smooth conchoidal fracture, much shattered.	1 ft.

The following fossils occur in the member A: *Favosites Alpenensis*, *Acervularia Davidsoni*, *Phillipsastræa Verneuili*, a

*Little has been done in the paleontology of this region but to make identifications on the spot, as far as I was able. The lists of fossils given may seem to possess but little practical importance. They possess, however, a scientific importance, and, indirectly, a practical importance; and I feel assured there will be not a few readers of this Report who will scan these lists and geological sections with interest.

branching Cyathophylloid, *Fenestella* (small fenestrules) *Fenestella* (large fenestrules) *Serpula*, *Strophomena nacrea*, *Strophomena* (large), *Tropidoleptus carinatus*, *Spirifer mucronatus*, *Spirifer sp?*

The following occur in the three upper members: *Favosites Alpenensis*, *Zaphrentis*, *Acervularia Davidsoni*, *Chonetes* (small, flat,) *Chonetes* (winged, large,) *Atrypa reticularis*, *Terebratula Romingeri*, *Nuculites*.

The strata at this locality seem to be the same as at the saw-mill on Bear creek, and their position is apparently above the Stromatopora beds at 856.

Proceeding about 100 rods along the shore we reach 858, a bluff 50 feet high, mostly covered by clay, pebbles and and sand. Some rocks containing *Acervularia Davidsoni* outcrop near the base of the bluff, and the place of these beds can be traced back under the soil-covered ridge to 857, but their stratigraphical relation to the rocks at 857 is very obscure.

On the S. W. ¼ Sec. 2 T. 34 N. 6 W. (861) occurs another outcrop, remarkable for the abundance and beauty of the fossil corals which it furnishes. The rocks embracing this deposit of corals I propose to designate as the "Acervularia Beds," and the particular stratum in which they are most abundant the "Coral Bed."

Section of Acervularia Beds (861.)

D.	Shale, bluish, argillaceous, imperfectly seen at top of bank	2 ft.
C.	Limestone, varying from dark to light gray, in beds from one to four feet thick, with a rough, somewhat granular fracture. Considerable argillaceous matter in the upper part. Few fossils..........	23 ft.
B.	Limestone, light or yellowish buff, varying to dark chocolate, argillo-calcareous, breaking with smooth fracture into irregular, sharply angular fragments, rather even-bedded in layers 6 inches to 2 feet thick. In the upper part alternating with bands of black bituminous calcareous shale and blue clay, 6 to 12 inches thick. The clay beds abound in beautifully preserved corals—*Acervularia Davidsoni*, *Favosites Alpenensis*, *Zaphrentis Traversensis*, &c. The bituminous bands burn quite freely, and have frequently passed for deposits of mineral coal	17 ft.

A. Limestone, grayish brown, compact, argillaceous, uneven-bedded, with smooth conchoidal fracture, embracing in its upper part a 4 inch stratum of black bituminous argillaceous limestone replete with *Atrypa reticularis* and considerable numbers of *Stromatopora* and *Acervularia Davidsoni* ....

The following additional species occur at this locality in Bed B: *Favosites explanatus*, *F. mammillatus*, *Callopora*, *Fistulipora* (2 sp.) *Aulopora* (2 sp.) *Trematopora*, *Fenestella*, *Spirorbis*, *Crania crenistria*, *Crania* (sp?) *Aulopora cyclopora*, *Cystiphyllum Americanum*, *Atrypa* sp? *Tropidoleptus* (3 sp.) *Terebratula Romingeri*, *Strophodonta demissa*, *Cyrtia Hamiltonensis*, *Spirigera concentrica*, *Spirifer mucronatus*, *Spirifer* (3 unrecognized species), &c., &c.

The stata embraced in the above section seem to be the equivalent of the eminently fossiliferous and often argillaceous beds well known at other localities, as Partridge Point in Thunder Bay, Widder and Saul's mills, in Canada West, and Eighteen-mile creek in New York. Their stratigraphical correlation to the other outcrops along the shore of Little Traverse bay is less obvious, as the coast line runs along nearly in the strike of the formation. As, however, marked lithological and paleontological distinctions exist at the different exposures, it becomes necessary to decide upon their actual order of sequence, however provisionally we do it. The difficulty is enhanced by the presence of numerous undulations of the rocks in the direction of their strike. At the locality under consideration the dip is toward the east or northeast, so that the strata would be carried under 857; but there are sufficient grounds for presuming that they rise again and pass *over* 857. Indeed, the resemblance between the rocks at 857 and the lower part of 861 is sufficiently exact to indicate this superposition. Moreover, we have found on the opposite side of the State a similar superposition, where the coral beds of Partride Point hold a place above the bituminous Tropidoleptus Beds of Thunder Bay Island.

So far, therefore, we may be justified in assuming the following order of superposition of strata of the Hamilton group.

3. Acervularia Beds, 858, 861.
2. Tropidoleptus Beds, 857. Bear creek. Saw-mill.
1. Stromatopora Beds, 856.

Rocks apparently identical with those of the last locality outcrop again at 862—S. W. ¼ Sec. 4 T. 34 N. 6 W. The coral clay bed is thinner and less exposed. The following is the section:

Section at 862.

C.	Limestone, buff, massive but shattered, crinoidal stems abundant in the upper part..............	15 ft.
B.	Coral clay.....................................	8 in.
	Limestone as above the clay.....................	2 ft.
	Lignite, calcareous and earthy, one to...........	3 in.
	Limestone, buff, thick-bedded, shattered, with bands of lignite. Contains *Acervularia*, *Stromatopora* (wide cells), *Zaphrentis*, *Favosites*, *Cyrtia*, *Tropidoleptus*, and *Gomphoceras*....	15 ft.
A.	Limestone, dark, fine, compact, thin-bedded, with conchodial fracture, extends under the water..	12 ft.

The dip here is quite rapid toward the west, but the strata rise again in the distance of about half a mile, at 863, where we find a section as follows, embracing a dome-like elevation of the strata, from the summit of which they dip in opposite directions:

Section at 863.

B.	Limestone, buffish, broken. Contains *Stromatopora* and *Acercularia*, and in the upper part, numerous crinoidal joints. (Thickness not nonoted)....................................	
	Limestone, similar to above, thick-bedded.......	4 ft.
A.	Limestone, dark, fine, compact, thin-bedded, breaking with conchoidal fracture. Extends under water..............................	8 ft.

Thirty rods further west these strata arch up again, disappearing finally wlth a westerly dip.

The next outcrop—at 865, Sec. 1 T. 34 N. 7 W.—presents strata of very different physical characters, in a bluff about a mile long, and rising about 20 feet above the water level. The whole thickness of strata exposed is about 41 feet. The formation presents an undulating section, showing not less than four considerable synclinal axes, and finally disappears with a westward dip.

Section of the Buff Magnesian Beds (865.)

E. Limestone, brownish-buff, magnesian, arenaceous, moderately coherent, vesicular, thick-bedded, more grayish in the upper part, contains a few casts of shells in the lower part............... 15 ft.

D. Limestone, darker colored, somewhat argillaceous, in broken layers from 1 to 4 inches thick. Contains *Nuculites*.............................. 6 ft.

C. Limestone, brownish-buff, magnesian, silico-argillaceous, porous, vesicular in streaks, in beds from 1 to 2 feet thick. Contains a band of *Favosites*. Reaches to water level at east part of the exposure; further west is succeeded by the following:.. 15 ft.

B. Shale, calcareous, soft, blue..................... 5 ft.

A. Limestone with *Acervularia* comes to view only at one point.................................

There is great difficulty in deciding upon the stratigraphical position of this section. I think, however, it lies above any rocks thus far described, because rocks which I assume to be the Acervularia Beds are seen to lie beneath these thick-bedded strata at one point in the section. Moreover, the rocks in question finally disappear with an eastward dip, and range themselves apparently but a short distance below the uppermost strata exposed near Antrim.

The next exposure on the bay shore is seen at Pine River Point—880, N. W. ¼ Sec. 28 T. 35 N. 8 W. A limestone reef extends around the point, and just on the south of the point the rock rises in a broad swell, affording the following section:

Section at Pine River Point (880.)

D. Shaly bituminous bands, corresponding perhaps to the Lignite of 862..........................

C. Limestone, containing *Acervularia*, *Tropidoleptus*, *Favosites*, *Zaphrentis*, *Strophomena nacrea* and a little *Stromatopora*........................ 4 ft.

B. Limestone, very shaly and thinly laminated, containing *Fenestella*, *Stictopora*, *Tentaculites*, *Trematopora*, *Chœtetes*, *Chonetes scitula*, *Tropidoleptus* (3 species), *Cyrtia Hamiltonensis*, *Spirifera Marcyi* (but with extended wings four inches broad along the hinge) *S. Marcyi* (typical) *S. mucronata* (4 inches broad), *Strophomena* (with regular clean ribs and flat dorsal valve) *Spirigera concentrica*, *Terebratula*?................. 10 ft.

A. Limestone, thick or thin-bedded, dark, highly calcareous, with green stains. Contains *Atrypa reticularis*, *Spirifer mucronatus*, *Strophomena nacrea*, &c.................................... 5 ft.

It would appear that the body of this exposure is in the same horizon as that at 857—the "Acervularia Beds," coming in above. It is obvious that the general dip of the strata at this point is toward Pine river, since the great abundance of *Acervularia* on the shore between here and Pine river proves that the "Acervularia Beds" at the top of the bluff pass under the harbor of Charlevoix. This conclusion is corroborated by the fact that, in travelling north, after passing that portion of the beach on the north side, in which *Acervularia* most abounds among the fragments, we succeed to enormous quantities of hard, fine and sharply angular fragments, whose position is not far above the "Acervularia Beds" (865, D). Mingled with these, moreover, are worn fragments of the brownish-buff magnesian beds of 865. It appears, therefore, that the rocks dip from both directions beneath the harbor of Charlevoix, and that Pine river finds its outlet along a partial synclinal axis, produced by local undulations of the strata.

The "Acervularia Beds" rise to the surface again at 881—on the line between secs. 29 and 32 T 34 N 8 W; and stili again at 882, W ½ sec. 8, T 33 N 8 W.

The last out-crop of the limestone is at 884, N E ¼, sec. 34, T 33 N 9 W, Emmet county, at which the following exhibition of strata is observed:

Section of "Chert Beds" (884).

E. Limestone, gray, in beds one to two feet thick, very hard, with cavities containing sulphide of iron, and calcareous spar.......................... 11 ft.

D. Limestone, gray, in laminæ a quarter of an inch thick, with intervening sheets and concretions of chert. Contains a few *Favosites*............. 9 ft.

C. Limestone, brown, in beds one foot and less in thickness.................................... 4 ft.

B. Limestone, bluish, shaly.......................... 1 ft.

A. Limestone, bituminous, irregular, broken.......... 1 ft.

The dip here is toward the southeast. The rocks seem to be quite distinct lithologically, from any others along the coast.

The thinly laminated or shaly limestone beds (D) graduating into, or alternating with, thicker limestones, resemble the rocks at 880, B, but, if identical, the abundant fossils of the last-named locality would scarcely be entirely wanting. A very peculiar character is also imparted by the abundance of chert. The hard massive limestone above these beds is not seen elsewhere, and constitutes, so far as observed, the uppermost member of the Hamilton limestones, since the dip at this place, would bring it immediately beneath the "Black Shale," which makes its first appearance about a mile further south.

Putting together the observations made at the various points, we are enabled to arrive, for the first time, at some definite idea of the order of sequence of the various members of the group of Hamilton limestones. This sequence may be thus exhibited:

V.	Chert Beds, (884)	24 ft.
IV.	Magnesian Beds, (865)	35 ft.
III.	Acervularia Beds, (858, 861, 862, 863)	23 ft.
II.	~~Tropidoleptus~~ Beds, (857, lower part of 862, 880, 881)	15 ft.
I.	Stromatopora Beds, (855, 856)	44 ft.
	Total	141 ft.

The Acervularia Beds probably find their equivalent in the upper part of the bluff at Partridge Point, in Thunder Bay, on the opposite side of the State, and again at Widder and Saul's Mill, in Canada West. The Tropidoleptus beds are found reproduced in the bituminous limestone of Thunder Bay island, and the lower falls of Thunder Bay river. The Stromatopora Beds are seen emerging from below the water level on the northeastern side of Thunder Bay island. The Magnesian and Chert Beds have not as yet been elsewhere identified—though we find a series of limestones near the upper falls of the Thunder Bay river, which have not yet been correlated with the other members of the group.

The Hamilton limestones sweep across the mouth of Grand Traverse bay and determine the general trend of the coast from Light House Point to near Frankfort on the Lake. The water at the mouth of the bay shoals to 10 or 15 fathoms, gradually increasing in depth southward in the direction of the

dip of the rocks to 103 fathoms opposite Old Mission; while on the north, the increase of depth is more abrupt, corresponding to the sublacustrine escarpment. The limestones of this group form a reef about Light House and Cathead points, and again in Canfield's harbor. They form the basis of that tongue of land known as Carrying Point and of Bellow's island off the mouth of Northport harbor. It is probable that the same formation constitutes the foundation of the Manitou islands, since the depth of water between the North Manitou and Pyramid Point (or North Unity) does not exceed 25 fathoms in the deepest part, and shoals abruptly in both directions to 7 fathoms and less.

5. Shales of the Huron Group.—In following the shore from Little to Grand Traverse bay, we find the "Chert Beds" succeeded, within the distance of a mile, by an outcrop of bituminous shale. This first appears at 888—Sec. 3 T. 32 N. 9 W., Antrim county. It rises toward the south and finally attains a thickness of about six feet. It is a rather hard, black bituminous shale containing iron pyrites, and, in the lower part of the exposure, some bands of silicious shale looking like a recurrence of the thin chert beds of 884. On exposure, the shale cracks into multitudes of small angular fragments and finally disintegrates.

This bed can be traced in a bluff a little retired from the shore and covered with soil, to 889, about forty rods distant, where it again outcrops in a bluff about 15 feet high, presenting nearly the same lithological characters as before. The oxydation of the pyrites, on exposure to the air, produces a reaction which forms a whitish efflorescence of sulphate of iron, or copperas, on some of the exposed surfaces, and thus greatly disguises the real characters of the rock.

The same formation outcrops again at 890, which is only about 20 rods south of 889. The lithological features remain the same, though the entire thickness of the black shale here exposed is about 20 feet—some enthusiastic, but deluded, searchers for coal having opened an excavation about six feet in depth.

At 891 — S. W. $\frac{1}{4}$ Sec. 11 T. 32 N. 9 W.—is another and important exposure of this formation, giving a view of about 20 feet in thickness. The shale for an interval of about 40 rods exhibits evidences of some geological disturbance. The strata are sometimes abruptly broken into huge angular blocks standing at all angles. It is difficult to decide what agency frost may have had in producing these dislocations. At a spot a few rods further south, however, are seen two narrow, nearly vertical fissures, now filled with calcareous spar. The whole mass of shale is intersected by divisional planes, making an angle of 70° with the stratification. No dip appears along the general face of the section, but at a notch in the coast line there is seen a dip of $6\frac{1}{2}$° toward N 51° E, which is nearly in the direction of the strike of the formation. It will be observed here as elsewhere throughout the peninsula, that the normal dip of the formation is quite imperceptible, and the only dip which can be detected is merely local, produced by the undulations of the rocky sheets, and may be in any direction whatever.

From this shore the bituminous shales strike toward the northeast, and are next known on the north side of Pine lake, about 6 miles from Pine river dock. The locality—868— N. E. $\frac{1}{4}$ Sec. 3 T. 33 N 7 W—is about 20 rods back from the shore of lake Michigan, at a point about one mile south of Frankfort, in Benzie county, as I have been informed. In the intermediate distance no actual outcrop is at present known. As these shales, however, are extremely friable, and their fragments could not bear the violence of a prolonged transportation, I consider it sufficiently exact for a provisional determination, if we assume the place of outcrop of the formation to lie along the belt of most abundant surface fragments. Relying upon this criterion, we are led to infer that the black shale strikes the west shore of Grand Traverse bay, in the neighborhood of New Mission, and passes thence southwest to Carp lake, which it crosses about a mile below "the narrows." It is next reported about six miles east of Glen Arbor, but I cannot vouch for the statement. I have, however, seen fragments to the southeast of Glen lake in the presumed trend of the formation.

The black shale thus traced is the same formation as that in Thunder bay on the opposite side of the State, at Kettle Point, and at various other localities in Canada West. It is the equivalent of the "black slate" of Ohio, Indiana, Kentucky and Tennessee—extending even into Alabama. It is the Genesee shale of the New York geologists. Its identity with the Genesee shale rather than the older Marcellus shale with which it was formerly identified, is established by its stratigraphical position both in Grand Traverse and Thunder bay. It is ranged immediately above the limestones of the Hamilton group instead of below them, in the place of the Marcellus shale. Moreover, the black shale of the Huron group, though almost uniformly destitute of marine fossils, has at length afforded me a few specimens from near the mouth of Bear Creek, in Canada West. Among these I identify *Discina Lodensis* and *Leiorhynchus multicosta*— species known to be restricted to rocks above the Marcellus shale in the State of New York.

The black shale of the Huron group is known to be succeeded in ascending order by a great thickness of whitish or greenish and more or less calcareous shales and clays ranged under the same group, though thus far totally unproductive of fossils for the determination of their affinities. The most conspicuous outcrop is seen on the east shore of Grand Traverse bay at 893 —Sec. 36 T. 32 N. 9 W., Antrim county — extending thence southward for half a mile or more. It seems to be formed by a gentle swell of the formation, with minor subordinate undulations. The rocks are a calcareo-aluminous shale, occurring in layers from half an inch to two or three inches in thickness. In some portions of the exposure, the layers are somewhat arenaceous, and at times assume the characters of a shaly argillaceous sandstone. The whole thickness exposed is about 15 feet. Two noticeable folds occur at this exposure within 30 feet of each other, and a third a few rods further north. The first and last present each a downthrow of about a foot. The middle one is much the greatest, presenting a downthrow of about four feet. These dislocations are not properly faults, for the strata are not fissured, but rather folded as if by a powerful lateral pressure. This is as great a disturbance of the strata as

has been noted in the lower peninsula—a similar one occurring in rocks of nearly the same age in the neighborhood of Pt. aux Barques.

The green shales strike southwest across the bay, but no actual outcrop of rocks of this character has been observed in that direction. A reef of light calcareous shale exists off Mission Point, and, judging from knowledge of the formation obtained in other parts of the State, the position of this reef is probably above the green shale, but not far removed. Striking diagonally across the "Peninsula," the light calcareous shale appears just beneath the water level on the north side of Tucker's Point, —Sec. 17 T. 29 N. 10 W.

I have not discovered the means of tracing the green and light colored shales any further. It may be assumed, however, that their strike continues southwesterly along a line nearly parallel with the outcrop of the black shale. Their thickness is not adequately indicated by the few exposures accessible, since, in other portions of the State we find it to reach four or five hundred feet.

It is probable that this series of greenish and light colored, argillaceous and arenaceous shales corresponds to the Portage group of New York. If the overlying Marshall sandstone should finally be shown to occupy a position above the Chemung group of New York, it will become necessary to admit that the shales under consideration embrace both the Portage and Chemung groups of New York. In this case, the Huron group, as orginally defined, will extend from the bottom of the Genesee shale to the top of the Chemung group.

6. Marshall Sandsone.—No stratified rocks higher in the series than the light shales have been observed within the limits of the Grand Traverse region. There are, however, geological reasons for believing that the southeastern portion of this region is underlaid by the buff, and triable sandstone of the Marshall group, which immediately succeeds the Huron group. Nothing more than an approximate indication of the boundary of this sandstone can be made; and this has been attempted on the map, by drawing a line so as to cut off nearly

the whole of Kalkasca county, and the southeastern angles of Antrim and Grand Traverse counties.

7. Drift Materials.—All parts of the Grand Traverse region, like other portions of the lower peninsula, are buried beneath accumulations of sand, gravel and clay, entirely destitute of a stratified arrangement, or presenting only a confused or irregular stratification. These deposits are the product of geological agencies that have been at work during the last period of the world's history. Their average thickness in this region is unknown. It is probable, however, that they are 50 feet thick at Northport, 60 at Sutton's bay, 100 at Traverse City, and from two to four hundred in the interior of Leelanaw and Benzie counties.

If we examine the structure of these deposits, we find the surface generally composed of sand, with occasional belts and patches of clay. The sandy constitution extends downward a varying depth, sometimes 50 or 100 feet; but we always encounter, sooner or later, one or more beds of clay. The clay deposits are in the form of vast sheets or basins, inclining at all angles, overlapping each other in various ways, and disposed at various depths, with sand both above and below. The bottom of the drift accumulations, however, is made up, generally, in this, as in other regions, of an enormous bed of clay, pebbles and boulders, resting on the outcropping edges of the rocks.

If we examine the mineral constitution of the Drift deposits, we find that most of the boulders and pebbles of the underclay are derived from granitic, syenitic, dioritic, quartzose and gneissoid rocks, and micaceous, talcose, hornblendic and silicious schists. No such rocks are found in place within 150 miles. These fragments have been transported from the upper peninsula of the State. We find corroboration of this opinion in the discovery of masses of native copper mingled with the other materials. One such mass found near Northport weighed —— pounds, and was sold for eighty dollars. If we examine the fragments of rock disseminated through the arenaceous and more superficial portions of the Drift, we discover, from their mineral character and their fossil remains, that they have been to a great extent derived from the rocks im-

mediately underlying, or outcropping but limited distances towards the north. The coarser Drift materials are, therefore, partly of local and partly of foreign origin. The source of the fine sand and the fine argillaceous deposits is somewhat more obscure. Without attempting to elaborate the evidences, it is enough to state that the boulder clay is believed to have had a northern origin, while the fine sand may have been derived from rocks of various ages, removed to various distances from their place of deposit, but is believed to have been mainly derived from arenaceous limestones of the Hamilton, Corniferous and Onondaga salt groups. The innumerable fragments of these limestones — especially the Hamilton — disseminated through the soil and subsoil, have been for ages undergoing a slow decomposition. The calcareous matter escapes in a state of solution and affords an important fertilizing constituent of the soil, while the imperishable grains of sand loosened from their bonds by the solution of the calcareous cement, become a principal portion of the finer material of the soil.

It is a very general opinion that the ruggedness of some portions of the Grand Traverse region is caused by disturbances of the underlying strata. I have, however, failed to discover any correspondence between the configuration of the surface and that of the underlying rocks. The hills are mere piles of Drift materials. The Drift was originally left with an uneven surface, but the depressions have been subsequently further scooped out by the erosive action of rains and torrents. The same agencies are continually wearing down the hills by removing the finer and looser materials to the valleys. If the configuration of the hills be attributed to uplifts of the underlying rocks, this is to suppose that the underlying rocks have at some time undergone a great degree of disturbance — much greater than the appearance of the rocks would warrant at any place where we have been enabled to inspect them. We know that everywhere else the strata of the lower peninsula repose in nearly horizontal planes. It is only in eruptive regions like that of Lake Superior, that we find the rocks forming the backbone of the hills.

But we need not speculate on the constitution of the hills. The erosion of lake Michigan along the eastern shore has gnawed away the land, till in some instances, the water-line has been carried to the very heart of the highest eminences in the country. The sloping lakeward faces of Mount Carp, North Unity, Sleeping Bear Point, Empire Bluff and Pt. aux Bees Scies are natural sections through the highest parts of some of the hills. In every case they fail to disclose any rocky ledges, but on the contrary, exhibit accumulations of pebbles, sand and clay to the very water's edge.

The topography and vegetation of Sleeping Bear Point have been already described; and I have just stated that this prominent land-mark from the lake is merely an enormous pile of diluvial rubbish. Toward the base, thick bands of pale bluish and purplish clay crop out, separated by beds of gravel and sand. Some portions of the surface also expose masses of gravel rendered adhesive by an intermixture of clay. Here and there a huge boulder protrudes above the general suface, polished like the smaller fragments, by the incessant pelting of sand particles driven before the wind. Much of the plateau is strewn with small angular fragments of chert; and it was long before I accounted for the preservation of their sharp angles among deposits that have suffered so much from attrition. I discovered at length a few large boulders of chert-bearing limestone—apparently from the Chert Beds of the Hamilton group, as I subsequently learned—in which imbedded masses of chert had been shattered *in situ*, perhaps by the action of frost. The dissolution of the inclosing limestones loosens the cherty chips, and the winds and rains strew them over the bald surface of the plateau.

The beds of clay at the bottom of the Drift are frequently found so free from pebbles and so evenly stratified as to be easily mistaken for some member of the argillaceous series of the Huron group. This is the case with some of the beds outcropping in the high beach of lake Michigan, between Leland and Cathead Point, as also at North Unity and Sleeping Bear, and on the west side of the Peninsula south of Bower's harbor. In other cases the similitude of an older formation outcropping

in situ is sometimes assumed by beds of fine sand either cemented by carbonate of lime, so abundant in the soil, or simply stuck together by clay. Phenomena of this kind are observed in the bed and bank of a small creek at Provemont, and also on the east shore of Carp lake, north of "the narrows." The latter kind of formation is comparatively recent, as is proved by the presence of inclosed stems or leaves of modern vegetation, or the shells of fresh water molluscs, or by the occurrence of uncemented Drift beneath them. The former kind of formation may be assigned to its true position by observing whether, in any part of its extent, it embraces water-worn pebbles, or presents great and abrupt variations in constitution, in the regularity of its stratification, the thickness of the separate layers or the persistence of the dip.

8. Lignitic Deposits.—At numerous places in the Grand Traverse region we find accumulations of vegetable matter and silt presenting a brown or blackish color, and occuring under a somewhat stratified arrangement. These accumulations occupy a position above all the stratified rocks, and the indications are that they are of more recent date than the boulder clays. At the same time we often discover thick deposits of sand, clay and shingle resting above them. They occur at various elevations, from a depth of eight or ten feet beneath the water level of lake Michigan to the height of fifty feet above. The most noteworthy instances will be cited.

In the neighborhood of Brownstown, at the southern termination of the green shale already described, occurs the following series of strata:

Section of Lignitic Deposit.

F.	Fine yellow sand—the subsoil of the region.......	12 ft.
E.	Small boulders, pebbles and coarse sand with shells of *Melania* and *Physa*......................	7 ft.
D.	Clay, soft, arenaceous and bituminous...........	2 ft.
C.	*Lignite*, somewhat impure, containing stems of cedar and other exogenous vegetation, passing above and below into a more argillaceous state..	3 ft.
B.	Clay, dark gray, very tough, with some sand and small pebbles and bituminous matter..........	2½ ft.
A.	Green clay, appearing to be produced by the disintegration of the green shale which holds a position immediately below, though not in juxtaposition,	2 ft.

The clay, lignite and green shale lie nearly in the same level, and their succession is made out only by carrying the observations laterally for a short distance. The lignite beds are spoken of as bituminous. They are so to some extent, but most of the vegetable matter is rather in a peaty or carbonaceous condition.

The foregoing observations were made in 1860. At the present time a large part of the exposure is covered up by sand, which has run down from above. But, on the other hand, we were now enabled to make observations which were not made five years ago. The lignitic bed is found passing under the sand which intervenes between the bluff and the water's edge, and can be seen beneath the water at a distance of three rods from the shore. Moreover, I was informed by a fisherman, that they penetrate it in driving their stakes for pound nets where I saw them, at the distance of a third of a mile from the shore, in water said to be eight or ten feet deep.

The occurrence of this deposit at such a depth beneath the water level, and at such a distance from the shore, renders it necessary to adopt with great caution, any explanation identifying it with an ancient accumulation of drift wood stranded on the beach. At the same time there are not sufficient evidences of its sedimentary origin; especially since, at other localities, a similar formation is found at considerable elevations above the lake.

On the east side of Carrying Point, near Northport, I observed a similar deposit at the water's edge, and extending a few inches beneath the surface. This rests on the undulating surface of a shingle beach, and, in one or two places, is seen to extend back into the borders of the forest, passing under the recent accumulations of leaves and shrubbery, and presenting the ordinary characters of a peaty deposit.

Again, on the sloping face of Sleeping Bear Point, in the vicinity of the "Little Bear," are seen bands of dark, lignitic matter, forming irregularly disposed belts along the exposed section. On examination, some of these are found to consist of sand, mingled with peaty particles. Above and below is

blown sand, and the whole mass is apparently a mere dune formation—the peaty particles assorted out by eddies of wind. These peaty particles, however, had their origin in the turfy soils with which some portions of this Point have, at some time, been covered, and relics of which are found still preserved, and presenting, in other places along this bluff, outcropping beds of better characterized lignitic material.

Similar accumulations of peaty or lignitic matter are exposed by the erosion of most of the streams emptying into Carp lake from the west; also about a mile northwest from Traverse City, in the bed and banks of a creek; also on Peter Stewart's land, Sec. 17 T. 29 N. 10 W., on the Peninsula; also at Whitewater, Sec. 21 T. 28 N. 10 W., on the land of A. T. Allen. At Northport, in the bed of the creek back of the Traverse Bay Hotel, is a mass of bedded peat containing fresh water shells, and, in places, becoming marly. In another situation, and deprived of its shells, this deposit would pass for lignite; but in this situation, with springs oozing out of the banks, and fresh water shells so abundant, the deposit can scarcely be regarded as anything different from ordinary peat.

(Are not these Lignites Cretaceous?

From the observations made on the lignitic accumulations of the Grand Traverse region, I am led to think that the principal deposits are not sedimentary accumulations formed in the bottom of the lake (and bay) near the shore; nor masses of stranded drift vegetation; nor materials bedded in the Modified Drift by either marine or lacustrine action at heights above or below the present water line; nor do I think changes of level in the lake waters have had any connection with their occurrence above or below the present water level. They seem to be ancient peat beds formed in situations kept moist, in some cases, by access of water from the lake, in others by the percolation of spring water from contiguous sand banks. They may hence occur at any elevation above the water level, and present exact adaptations to the inequalities of the subjacent surface. The erosion of the lake and bay shore has caused these peaty areas to be invaded by the waves, which, while they could not, without unusual violence, rend to pieces the peaty matter bound together as it is by interlacing stems

and fibres, could nevertheless wash out the fine sand on which the peat bed rested, and cause it, by degrees, to settle down to the water level, and even beneath it.

XI. ECONOMICAL IMPORTANCE OF THE VARIOUS GEOLOGICAL FORMATIONS.

1. Salt.—The Onondaga salt group, which underlies the entire region, is the source of supply of the gypsum and brine of central New York. It furnishes the gypsum of the Grand River region of Canada West, and of Sandusky bay in Ohio. It is also known to contain a large supply of gypsum in this State at Little Pt. au Chene, west of Mackinac. I have also shown that the salt wells of Port Austin and St. Clair, in this State, are supplied from this source; and have expressed the opinion that this group of rocks will be found equally productive in other portions of the lower peninsula. The position of the Grand Traverse region is such that I should be led to hope for success in boring into this formation. The well authenticated existence of an ancient salt spring on the neck of land connecting Harbor (or Hog) island with the Peninsula, I should regard as a confirmation of this opinion, since, if a fissure existed in the overlying rocks, the brine would tend to rise by hydrostatic pressure, as through an artesian boring. Deacon Dame, of Northport, one of the oldest residents of the region, has furnished me with detailed information, which seems to fully authenticate the current tradition relative to the former existence of this spring.

Mr. H. G. Rothwell, of Detroit, likewise informs me that a salt spring exists on the southwest corner of Sec. 35 T. 26 N. 16 W., which is less than three miles from Frankfort, in Benzie county. Undoubtedly this spring is supplied from the same source.

Very great difficulty exists in estimating the depth from the surface at which the formation would be struck. If an experiment were to be made at the head of the East or West bay—points where the basin would be found most depressed, and the brine, consequently, most concentrated—we might venture

to make the following approximate estimate of the thickness of the intervening formations:

Drift Materials	120	feet
Light and Black Shales	400	"
Hamilton group	140	"
Corniferous limestone	200	"
Onondaga Salt group	50	"
Total	910	"

The light and black shales (Huron group) attain a thickness, in the southern part of the State, of about 600 feet, but I believe the indications do not justify so high an estimate for the Grand Traverse region. The Corniferous limestone is about 300 feet thick at Mackinac, but not over 100 feet thick in Monroe county. I think the question of salt would be sufficiently tested within 1000 feet.

2. PETROLEUM.—The Hamilton group is the formation in which most of the oil is obtained at Oil Springs, Petrolea and Bothwell in Canada West. It consists there, as here, of a series of limestones, shales and shaly limestones. The oil accumulates in the loosely constituted shaly limestones; in the numerous small fissures of fissile clay shales; in vertical fissures and irregular cavities in the massive limestones, and in the pores of a buffish, porous magnesian limestone at the bottom of the series. The deposits of oil possess no considerable lateral extent, since wells even upon the same acre of ground seldom interfere with each other. The oil also accumulates, sometimes in enormous quantity, in a bed of gravel or sand reposing at the bottom of the Drift materials upon the top of the rock. This is a thick oil used for lubricating purposes.

At Petrolea the black (or Genesee) shale is not found overlying the rocks of the Hamilton group. At Oil Springs the thinning edge of this formation is encountered in about the middle of the productive area. This thickens toward the west, until, in some wells not over a mile distant, the formation has attained a thickness of 40 to 50 feet. At Bothwell the black shale occurs of considerable thickness. The same is also true of the undeveloped regions of Wyoming, Dawn and Chatham in the peninsula of Canada West.

There are belts within the Grand Traverse region corresponding in geological position with each of the localities just named; and I believe there are good geological reasons for anticipating success in an attempt to obtain oil. The region from the head of Little Traverse bay to Northport, and thence to Leland, Glen Arbor and Frankfort, is situated like the region about Petrolea, except that the drift materials, inland from the lake shore, are accumulated in deeper masses. The best situation for making experiments would be at points sufficiently covered to have prevented the evaporation of the oil, but yet sufficiently depressed to avoid unnecessary boring through the overlying sands.

The line which marks the western boundary of the Genesee shale—already indicated—marks out a belt of positions similar to that of Oil Springs in Canada West; while a strip of country a little further east would be found circumstanced similarly to the Bothwell oil region.

It cannot be expected that oil will be found generally and indiscriminately distributed throughout this area, but I should be surprised if half a dozen undertakings, judiciously located, should fail entirely of bringing the coveted fluid to light.

Surface indications are quite common throughout the region, of which the following are a few examples.

In a stream at Lindsley's house, at Sutton's Bay. Mr. de Belloy and I have demonstrated that this proceeds from a marsh half a mile distant on the hill-side. Strong indications exist also on the farm next north of Lindsley's.

On Carp lake, near the landing of Cornelius Jones, I saw a film of oil, and brought up bubbles of inflammable gas by stirring the bottom.

On the east side of the lake, a little further down, I saw similar indications. I saw the same again near the head of the north arm of the lake. Again, on the back part of Buckman's farm, and throughout that region, north of Leland, on low grounds.

On the west side of Carp lake, near the head, on land of James Nolan, I noticed indications; and also at numerous

points between Nolan's and Provemont. No smell was noticeable, and in many cases the oil was mixed with an iron film.

Mr. McPherson, living on the east side of the bay, about four miles south of Antrim, assured me that he had detected a strong smell of kerosene in passing the outcrop of green shale in that vicinity. One of his boys asserted that he found the smell so strong, one day, that he hunted long for the fragments of the jug of kerosene which he was convinced had been broken at the spot. Mr. de Belloy gives similar testimony to the occurrence of a strong smell in the same vicinity, at certain times. The same is also asserted by Mr. Blakely, living near Torch lake.

About two miles from Northport, on the road to New Mission, I saw a fine film of oil on standing water.

In the border of the swamp back of Deacon Dame's residence at Northport, are very characteristic indications. Gas also escapes at intervals in a spring near the house. In calm weather a copious escape of oil can be seen from Rose's dock. The oil rises and spreads in a fine film with dichroic refractions on the surface of the water. The same is seen again at the mouth of the creek near the dock.

Similar phenomena are seen on Manseau's creek at Pishawbey-town. So says Mrs. Page.

On the land of Rev. Mr. Smith at Northport, I saw abundant films of oil, with some iron. The same can be seen on standing water near the creek back of Traverse Bay Hotel.

On the northeast shore of Leg lake, I saw several small oil springs, with much iron.

On land of Rev. George Thompson at Leland, I saw slight petroleum indications near the house, and also about a cattle spring a quarter of a mile northwest of the house.

Supposed oil indications occur on railroad section 3 T. 32 N. R. 7 W., about a quarter of a mile from the north side of Pine lake.

In the low ground about the head of the West Arm of the bay, I noticed abundant films of oil on the surface of standing water.

The numerous instances in which the escape of oil and gas to the surface has been observed, tend to confirm very strongly the induction based on stratigraphical data, and afford full justification of attempts to reach, by boring, the reservoirs whence the oil escapes.

3. Clays.—The Drift formation, besides supplying an admirable quality of silicious sand for plastering, contains large deposites of pure clay for bricks and pottery. In some cases this clay is already mixed with a sufficient amount of sand for immediate use. Along the elevated beach north of Carp river, is an exposure of an enormous deposit of fine fawn-colored clay, quite free from pebbles of every sort. It is compact and somewhat fissile, but undoubtedly belongs to the drift formation. The same deposit outcrops again at North Unity, at Sleeping Bear and at Empire Bluff. At either point a manufacture of bricks could be established which would rival Milwaukie both in the cheapness of production and the fine quality of the bricks. Beds of excellent clay occur at Frankfort within the limits of the town plat.

Clay of similar quality, but somewhat mixed with boulders, occurs on the bay shore south of Antrim. A bed of boulder clay abuts upon the bay at New Mission, and forms the basis of the promontory on which the Seminary stands. A short distance back of Fisher's house at Glen Arbor, a land slide has uncovered an excellent bed of pure clay. At Antrim a second beach, a few rods inland, is formed by a bank of pink-colored, boulder-bearing clay.

It is a mistake to suppose the clay of the region is not adapted to brickmaking. No doubt limestone pebbles may become mixed with the clay employed, but a good article can be successfully selected. William Wilson informed me that he made 2,000 bricks from a bed of clay two miles below New Mission, and they proved unexceptionable. The color was that of Milwaukie bricks. Of the whole quantity not one has bursted from the presence of limestone pebbles. At Elk Rapids 100,000 bricks of Milwaukie color were made, and all were good, except a few made from material taken near the surface of the bed.

XII. FARM CROPS.

The descriptions which I have given of the nature of the soil and climate of the Grand Traverse region, will prepare the reader for the statement which I now make, that the region is capable of producing any crop which flourishes in the northwestern States, as far south as the latitude of Cincinnati. In order to give definiteness to the testimony which I am about to produce, I shall furnish names, localities and figures. Where anything is given on the authority of others, the production of their names will render them responsible for the statements.

1. WHEAT.—The staple crop of the region, at present, is winter wheat. The mildness of the autumn enables it to secure a good start, while the mantle of snow with which the country is covered during the winter, insures the crop against winter-killing. Very rarely I heard accounts of "smothering" in limited localities.

Mr. Hannah informs me that the average production of wheat about Traverse City is 25 to 30 bushels per acre. Morgan Bates, Esq., says the first crop of wheat pays for clearing the land. In 1864, he cleared 27 acres of heavily-timbered land, hiring all the labor. The clearing, fencing with temporary fence, seed, plowing part, sowing, harvesting and threshing, cost $892. The wheat raised was 560 bushels, which sold at Traverse City at $1.60 a bushel, amounting to $896. This yield is only 21½ bushels per acre, but Mr. Bates states that an unusual amount was wasted by improper harvesting. The land is now worth $30 per acre.

Rev. Merritt Bates published the following statement in 1863: Cost of clearing ten acres, fencing, seed, cultivation, $285. Product, exclusive of waste caused by threshing in the open air, 268 bushels, worth at the door $1.25 per bushel, $335 —besides straw worth $50.

James Orr, one mile south of Antrim, raised winter wheat, a sample of which was stated by dealers at Battle Creek to be the finest known in the State. William Johnson, on the east side of Elk Lake, raised this year 30 bushels of winter wheat

to the acre. In the Monroe settlement, in Grand Traverse county, winter wheat averages 28 bushels to the acre. In 1863, William Monroe raised 30 bushels, and his brother Henry 38 bushels to the acre.

2. Corn.—The variety of corn most prevalent is the yellow eight-rowed corn. It has been demonstrated, however, that dent and King Philip corn and other varieties, will ripen with certainty. I saw Mr. de Belloy and others husking corn fully ripe in the middle and latter part of September, and I was assured that the crop was sufficiently ripe quite early in September. I saw fields of corn fully ripe about the same time, near the north end of Carp lake, and also on the west side, toward the head of the lake. It was growing thriftily on the steepest hill-sides, in fields which, in some cases, had not been plowed. I saw dent corn fully matured and twelve feet high on the land of Stephen Perkins, near Long lake. At Leland, I saw ears of King Philip corn, raised by H. S. Buckman, which were 10½ and 11 inches long, well filled out and matured. I saw similar ears at Traverse City,—also luxuriant specimens of Ohio dent corn. Enoch Wood, four miles south of Elk Rapids, brought to market two loads of dent corn equal to any produced further south. Wm. Monroe informed me that he raises good crops of corn—some of which is dent corn. Dent corn was raised this year by E. P. Ladd, at Old Mission. Corn is not so sure a crop at Pine river.

3. Oats.—On the west side of Carp lake, I saw as good crops of oats as ever in my life. Mr. Hannah states that oats always bring an excellent crop. I saw in the office of Mr. Bates, at Traverse City, a bunch of oats 7 feet and 9 inches high, raised on land of John Cornell, 20 miles south on the Newaygo state road. The whole field is said to have been extraordinary, though I was assured that many farmers have raised fields of oats six feet high. Mr. Monroe informed me that he raises 50 bushels of oats to the acre.

4. Buckwheat.—As might be expected, buckwheat also flourishes luxuriantly. I never saw better fields than on the west side of Carp lake. The crop is generally said to flourish well, but is not perhaps extensively introduced.

5. Potatoes.—The finest potatoes of the country are produced in this region. The soil and climate seem to be admirably adapted to the crop. Thousands of barrels are shipped to Chicago annually. They often pass in the market for Mackinac potatoes, as that region had a reputation established many years ago. The potato grows without cultivation in the Grand Traverse region—the entire crop being often left in the ground till spring, and scattered tubers taking root in fields cultivated for other crops. Mr. Fisher, of Glen Arbor, had potatoes growing in a field where they were planted six years ago.

The potato grows large and smooth and is uniformly healthy. I saw at Traverse City, a Carter potato, raised four miles west of that place, on land of Rev. Merritt Bates, and measuring 8½ inches in length and 9 inches in circumference. In Campbell's store, at Northport, I saw three Peach-blow potatoes, weighing respectively 19½, 20 and 26 ounces. Deacon Dame informed me that he had raised 300 bushels of potatoes to the acre. He also says that a single hill sometimes yields considerably over a peck, and that whole fields will average a bushel to every eleven hills. This was done on land of Mrs. Daniel Knox, two miles west of Northport. Mrs. Page, of Pishawbey-town, says she raised from one hill a half bushel even full of Lady-finger potatoes. It was only one hill of a patch. Mr. J. W. Washburne says he raised on one stalk of Peach-blow potatoes, over a half peck—all large ones. This was in a half acre lot, the soil of which had been cultivated several years. W. W. McClellan, of Northport, showed me a potato of Clinton variety, raised on land of James Martin, 2½ miles north of there, which measured nine and seven-eighths inches in length and weighed 33½ ounces. Mr. Tilley, at Leland, showed me two potatoes of the Cazenovia variety weighing 18½ and 20½ ounces respectively, ten days after being placed in a dry atmosphere. They were raised two miles south of Leland. Mr. Gerard Verfurth exhibited a potato of the same variety, raised in the village, which weighed 27 ounces. I saw potatoes of the California variety, raised by Rev. Mr. Smith, of Northport, measuring 8½ inches in length, and a black Meshannock 8¾ inches long.

6. HAY.—Timothy hay proves a successful crop. Mr. Bates, of Traverse City, has 33 acres seeded, which he calculates will pay him the interest on $3,000. If it brings only one ton to the acre, he will receive a profit of $9 per ton, or $307 on the whole, which is ten per cent. on $3,070, or about $93 per acre. Rial Johnson, four miles south of Elk Rapids, has one of the oldest farms in the country, and raises superior Timothy hay. Mr. E. Pulcifer, south of Elk Rapids, got 19 loads of red clover hay from three acres planted to an orchard. He keeps nine cows, and makes butter and cheese for the market. He proposes to enlarge his dairy. I saw first rate Timothy hay in the fine, capacious barns of William Monroe, in Grand Traverse county.

7. OTHER CROPS.—Turnips grow with the utmost luxuriance, as I have observed on the west side of Carp lake, at various places about Traverse City, and along the road thence to Glen Arbor. Mr. Sprague, near Leg lake, in Leelanaw county, directed my attention to a fine field of turnips, and assured me that he once raised a flat turnip which weighed 17 pounds (!) Carrots grow well. Mr. Stewart, on the Peninsula, showed me a bed of carrots which were from two to three inches in diameter, the seed of which was planted July 1st. He showed me parsnips of a still larger size. I saw fine carrots back of Glen Arbor. Tomatoes ripen well. I met with them at various points. Mrs. Joseph Batey raised three tomatoes in the south part of Traverse township, which weighed 40 ounces each. Mrs. Dixon informed me that tomatoes do not mature well at Pine river. I saw an excellent crop of white beans at Rial Johnson's; and also large, plump marrowfat peas.

XIII. FRUITS.

As a fruit-growing region, it is doubtful whether any other part of the United States will compete with this. Apple trees were planted on the first settlement of the county, and have always grown well and borne luxuriantly. The characteristics of the trees and fruit are healthfulness, luxuriance and large size. Rev. Mr. Smith, of Northport, has a young orchard in which I saw various familiar varieties in a greater degree of

perfection than in any other part of the country. The average size of the Rhode Island Greenings was eleven inches in circumference—weighing eleven ounces. Seedling apple trees were loaded with fine winter fruit. Fine young orchards are coming into bearing on all parts of the Peninsula, and throughout the country south and southeast of Elk Rapids. Mr. Hannah, at Traverse City, has planted an orchard of about forty acres containing 1,000 trees. At New Mission, I witnessed the most beautiful exhibition of apples that ever met my eyes. An orchard on the seminary grounds, about 14 years old, was completely loaded with large, fair, richly-colored fruit of old and new varieties. It was a marvel of luxuriance and beauty. I saw whole trees borne down with apples from four to four and a half inches in diameter, and weighing from 14 to 18 ounces. These trees were planted and reared by Rev. Peter Dougherty, the intelligent and useful superintendent of the mission. I saw young apple trees flourishing lnxuriantly in the neighborhood of Glen Arbor, and in nearly all other parts of the region.

It was formerly supposed that the climate was unsuited to peaches, but different persons having from time to time planted a few peach stones, it was ultimately proven that the peach flourishes in perfection. At Leland, I saw trees laden with ripe fruit in September. At New Mission, the peaches which I saw were as great a marvel as the apples. Some measured eight and nine inches in circumference. The seedling fruit was so abundant that no attempt was made to gather it. Thomas Tyre, on the Peninsula, brought to market this year 75 to 100 bushels of peaches. Rial Johnson, on Elk lake, raised 200 bushels from a small orchard, the seeds of which were planted ten years ago. Rev. Mr. Smith, of Northport, succeeds with peaches. Mr. Fisher treated me with peaches raised at Glen Arbor. I saw thrifty trees growing on the farms back of Glen lake. Mr. Almon Young on the south side of Round lake, raised superb peaches; also Mr. Amos Wood, two miles from Elk Rapids. Mr. Wood's trees have been bearing regularly for six or seven years. Mr. E. Pulcifer, near Whitewater creek, raised 20 bushels of peaches. I

was informed that peach trees come into bearing in four years from the seed. I heard of only one instance of complaint of winter-killing of peach trees, and that was at Monroe's, 12 miles south of Traverse City and 20 miles from lake Michigan. Nectarines are raised by Judge Fowler, at Mapleton, on the Peninsula, and probably at other places. Plums produce profusely, and are exempt from all insect ravages. I measured a shoot of this year's growth five feet long on a plum tree in Mr. Fisher's yard at Glen Arbor. Mr. L. R. Smith, at Elk Rapids, raised one stem of Early Orleans variety which bore 22 plums, averaging four inches in circumference. He also raises the Washington plum. Rial Johnson raised five bushels of plums.

The different varieties of cherries thrive equally well. I saw flourishing trees on Mr. Smith's place, at Northport; also at Glen Arbor. Mr. Wm. J. Bland, at Elk Rapids, has a Bigarreau cherry tree that has borne regularly for four years. I saw thrifty trees on the place of E. Pulcifer.

Pears thrive wherever they have been tested. Mr. Smith's soil at Northport is probably peculiarly adapted to pears, and they flourish very finely. They do about equally well at New Mission. I saw good trees also at Glen Arbor, and in the Whitewater region. Mr. Smith also succeeds with quinces.

Grapes thrive admirably throughout the region—though wherever I saw them they were retarded in development by lack of pruning, by excessive crops, and by too much shade. I saw grapes bearing well at Leland. At New Mission, I saw Isabella and Catawba grapes ripened on neglected vines in a situation badly exposed to the sun. Mr. Smith's vines were literally borne down with their burden of ripe and unripe fruit in the latter part of October. L. A. Thayer, on the east side of Torch lake, raised superb Concord grapes. His vines have been bearing four years. Isabellas ripen early in September. Judge Fowler, at Mapleton, has matured Isabella grapes for four or five years past.

This region is the native home of the red currant, the red raspberry, and the blackberry. Currants are unsurpassed. Raspberries bear with the utmost luxuriance, either in the cultivated or uncultivated state. I saw ripe raspberries in Octo-

ber, on the Peninsula, growing on canes of the present year's production. The same canes bore green fruit and flowers. This phenomenon is of frequent occurrence. Mr. Tilley, of Leland, informed me that he had, on the last of October, ripe black-cap raspberries growing in his garden, on this year's canes. Strawberries flourish as well as in any part of the world. Mr. Hannah, of Traverse City, informed me that he raised this year 25 bushels from a piece of ground 50 by 75 feet. Mr. Stewart, on the Peninsula, assured me that he could pick strawberries in his fields every day from the first week in June till the approach of snow.

Few situations suitable for cranberries exist, but Mr. Fisher informed me that a marsh along Crystal creek produces them at the rate of 300 bushels to the acre, and he proposes to avail himself of this source of revenue.

The secret of the wonderful adaptation of this region to the production of fruit, is found in the characteristics of the soil and climate heretofore described. It is likely the sandy plains to the south of the East and West Arms of the bay will be found well adapted to the raising of peaches. The region best protected from danger of winter-killing and late spring frosts, lies between the bay and the lake, in Leelanaw county; and yet actual results demonstrate that the peach flourishes, hitherto without drawback, several miles east and south of the bay.

The recent discovery of the admirable adaptation of this region to the purpose of fruit growing, has caused very general attention to be directed to the subject. Almost every farmer is enlarging his plantations. When at Traverse City, on the 8th of November, I witnessed the arrival of 32 cases of fruit trees from the nursery of T. D. Ramsdell, of Adrian. Mr. Mace Tisdale, who had made contracts for this large supply, informed me that he was introducing $4,100 worth of fruit trees this fall.

XIV. THE INDUSTRIES OF THE PEOPLE.

The leading occupation of the inhabitants of this region must necessarily be the cultivation of the soil. Evidently,

however, in a country so densely wooded, the duty which first urges itself upon the attention of the new settler, is to effect a clearing. As pioneers generally desire to realize as speedily as possible the avails of their labor, the chopping and sale of "cord wood" has unavoidably engaged a large share of attention; and the shipment of cord wood to Chicago, and its supply to propellers running on the lakes, have become an important branch of business. In November last, the cost of chopping a cord of propeller wood was $1.25, and a cord of shipping wood $1.50. The difference is caused by the greater care requisite in the preparation of a cord which will pass the market regulations in Chicago. Propeller wood was selling on the dock at $3.00 to $4.00 a cord. Shipping wood on the beach was selling for $3.00 a cord; on the dock for $4.00. Freights to Chicago were exorbitantly high; but the state of things was evidently exceptional and temporary. Even at the existing charges for freight, the price in Chicago left a fair margin for profit to the shipper.

Thousands of cords of beech and maple wood, in the haste to effect a clearing, are simply chopped and burned on the ground. It is obvious that two or three potash establishments would save an enormous waste of ashes, and furnish a desirable convenience for the pioneer. I am not aware that the manufacture of potashes is carried on at the present time in any part of the region. It was suggested to me that a man prepared to buy ashes or "black salts," and to furnish in exchange such commodities as farmers generally need, would succeed in doing a profitable business. He should keep potash kettles for sale to farmers residing at distances too great to justify the transportation of the ashes. These kettles would be used in the manufacture of "black salts" on the ground, thus materially reducing the bulk of the article to be transported to the ashery. It is estimated that every acre furnishes from 350 to 500 bushels of ashes.

Another use to which the forest may be immediately converted is the manufacture of maple sugar. This branch of industry is mostly left to the unskillful and untidy management of the Indians. It is estimated that one man can manufacture

from 400 to 600 pounds of maple sugar in a season. This, at a season of the year when no other occupation than wood-chopping is practicable is a source of revenue which the pioneer ought not to neglect.

The manufacture of lumber is carried on only at two or three points, and though over 20 millions of feet are annually produced, it can scarcely be regarded as an occupation in which the people generally are concerned.

The manufacture of bricks and pottery, though not yet established, is destined to become an important branch of business both for home supply and for exportation.

The manufacture of wooden ware of all descriptions might be successfully carried on where the finest qualities of maple, beech, white and black ash and white pine are so readily accessible on the immediate shore of navigable waters.

Sagacious business men have, also, long since suggested the propriety of the erection of furnaces at Northport, Frankfort and other points, for the purpose of smelting the ores of iron from the upper peninsula. The ores of Marquette can now be delivered by railroad at Escanaba, which is only 85 miles by water from Frankfort, and about the same distance from Northport; while the almost inexhaustible forests of hard timber in the Grand Traverse region render it the most desirable portion of the State for the economical operation of blast furnaces.

XV. SETTLEMENTS.

Charlevoix, commonly known as Pine River, though scarcely within the limits of the Grand Traverse region, is destined to become an important point. It is a new settlement, having a substantial dock, a store and several private dwellings. It is claimed that eleven propellers have entered into arrangements for "wooding" at the dock next season. The dock and fifteen acres of land along the beach are owned by the New York Central Propeller Company. The river has four feet of fall at this place.

Antrim City has just been founded by Mr. L. H. Pearl, who has erected a substantial dock and engaged extensively in the sale of cord and propeller wood. The country back of Antrim

is becoming rapidly settled, and must soon demand the conveniences of a store and hotel.

Eastport is just founded by an enterprising gentleman of Detroit.

Brownstown is at present a mere fishing station.

Elk Rapids is by far the most important point on the eas side of the bay. It was founded by Messrs Dexter and Noble, who have made substantial and valuable improvements—erecting a first class dock, saw-mill and boarding-house, and opening a store, at which the surrounding country is supplied with all classes of goods at reasonable rates. Two hundred barrels of flour were made here in 1864. The Elk Rapids Eagle is published weeekly by E. S. Sprague, Esq. An appropriation of $3,000 has been made toward building a court-house and jail.

Petobego is the name applied to the settlement around Petobego lake.

Whitewater Post-office is located at the mouth of Whitewater creek.

Hoxie and Havilet have a dock at the southeast angle of the East bay.

New Sweden is a settlement, now nearly abandoned, whch clustered around the saw-mill at the head of the East bay.

Mapleton Post-office is located on Sec. 27 T. 29 N. 10 W. on the Peninsula.

Old Mission (Grand Traverse Post-office) is situated near the point of the Peninsula, on the east side, and was the first spot occupied by the white man.

Bower's Harbor, or Haight's, is a wood dock and point of shipment, near the head of the harbor.

Traverse City is the largest and most flourishing settlement in the region. It is situated at the head of the West Arm. It was founded by Messrs. Hannah, Lay & Co., who have erected very extensive and substantial docks for lumber and shipment, and have opened a wholesale and retail store, at which anything may be purchased, from a paper of pins to a steam engine. The saw-mill of this company is one of the largest and best equipped in the State. The place contains also a steam flouring mill which produced 500 barrels of flour in 1864, two good

hotels, one or two other stores, a school-house, blacksmith shops, shoe shops, a photographic establishment, and other places of business. The United States Land Office is kept at this place. The weekly Traverse City Herald is edited and published by Morgan Bates, Esq. The population of the place is perhaps one thousand.

Norris' is on Sec. 28 T. 28 N. 11 W. Here is a dock and a saw-mill.

At Lee's Point is a landing dock detached from the shore.

Sutton's Bay is a small village and post-office, with a detached dock for shipping purposes.

Pishawbey-town is an Indian settlement and Catholic mission.

New Mission (Omenia Post-office) is a mission sustained by the Presbyterian Board. A seminary stands here, taught by the intelligent daughters of Rev. Peter Dougherty, in charge of the mission.

Northport is a port of entry, and one of the oldest settlements on the bay. It was founded by Deacon Dame, who removed there from Old Mission. It has a population of six or eight hundred. It is furnished with one good hotel, and several stores. The harbor is a favorite place of refuge for vessels navigating the lakes; and the propellers have been very generally in the habit of wooding there—the arrivals amounting, as I am informed, to 400 a year. Northport has two good docks—Campbell's and Rose's. At the bight of the bay, two miles distant, is another dock, belonging to Burbeck and White.

Leland is a new settlement, at the mouth of Carp river. It is supplied with a saw-mill, a hotel, a boarding-nouse and store. Tbe place was founded by Fayette and Thies, who own one of the two good docks with which the port is provided. One thousand barrels of flour were manufactured here in 1864

Thomas Kelterhouse has constructed a dock, and commenced a settlement four miles north of Glen Arbor.

Glen Arbor was settled by John E. Fisher, six years ago. A good dock exists at this port, and Crystal creek affords water-power for a saw-mill and flouring-mill. Another dock has been built on the south side of the harbor.

On the north side of Empire bluff George Aylesworth is constructing a new dock.

Frankfort on the lake is a new settlement. The improvements in the harbor have been already described. The town site is beautifully located on a gentle southward slope, rising from an elevation of 10 feet above the lake to an altitude of about 200 feet in the back part of the town.

Benzonia is a new and enterprising settlement, founded by a Christian colony from Ohio. From a circular issued in 1864, I learn that the place has been selected with great care, as the seat of a Christian community and an institution of learning. One fourth of the entire amount of land purchased is consecrated to the endowment of the college. The church organization is Congregational in form. The sale of ardent spirits and tobacco, except as medicines, is prohibited in the vicinity of the college. The land is selling at prices ranging from three to ten dollars an acre—one-fourth of the profits going to the college. The secretary of the colony is Rev. C. E. Bailey, Benzonia, Benzie county. The president of the college is Rev. J. B. Walker, D.D.

The Carter settlement, in the south part of Leelanaw county, is a neighborhood on the road from Traverse City to Glen Arbor.

The Monroe settlement is similarly located on the road from Traverse City to Newaygo.

Provement is a settlement founded by Mr. A. de Belloy on the narrows of Carp lake.

The population of the Grand Traverse region, according to the State census of 1864, was as follows: Antrim county, 382; Grand Traverse county, 2,017; Kalkasca, 9; Benzie, 500; Leelanaw, 2,389. Total, 5,297. Within the past year this total has probably increased to 7,000, or over. The population of the township of Peninsula, by the same census, was only 479. It is now thought to be 1,000. Reliable judges estimate the accessions to Antrim county during the past year at not less than one thousand souls.

XVI. HIGHWAYS.

The propeller Alleghany, belonging to Hannah, Lay & Co., makes a weekly trip between Chicago and Traverse City, during the season of navigation, stopping at Northport. The lake propellers stopping at Northport afford communication between that place and other lake ports three or four times a week, on an average. Other means of communication, by propellers, are had from Pine river, Leland and Glen Arbor. Messrs. Hannah, Lay & Co. have placed a small propeller—the Sunnyside—on the bay, which, during the season of navigation, makes the round trip daily to all the more important settlements on the bay, and forms a ready, agreeable and most invaluable means of communication from point to point. Her trips have extended, twice a week, as far as Pine river. Besides these means of communication, small sail boats are always at hand to convey the traveler to his destination, in default of other means of conveyance.

Carp lake, besides small boats, is provided with two tugs, which make frequent trips to different points along the lake.

The common roads are of course new, and, except in the oldest sections, more or less imperfect. The beach forms a useful thoroughfare in summer, and the ice in winter. A system of State roads, however, has been put in process of construction, which is destined to prove an important instrumentality in developing the country. These are:

1. "The Allegan, Muskegon and Traverse Bay State Road," running from Allegan by Holland and Ferrysburg to Muskegon, thence by Pentwater, Manistee and Benzonia to Traverse City. (Act approved 12th Feb., 1859).

2. "The Newaygo and Northport State Road," running from Newaygo north by the Manistee crossing and the Monroe settlement to Traverse City; thence along the west shore of the bay to Northport. (Act approved 12th Feb., 1859).

3. "The Emmet and Grand Traverse State Road," running from Traverse City by Elk Rapids, Antrim, Pine River and Little Traverse to Mackinac. (Act approved 15th March, 1861).

These roads are all in process of construction. The last has been completed to Elk Rapids. The second is open to the Manistee river. The first is in use from Traverse City to Grand Haven. The latter road furnishes the only outlet to the region during the winter months. A stage, conveying passengers, freight and the United States mail runs regularly between Traverse City and Muskegon. A weekly stage runs between Traverse City and Elk Rapids.

Railroad communication with the southern portion of the State is much needed. Land grants were made, about ten years since, to three different companies, who undertook to open communication between the northern and southern portions of the State; but the difficulties of prosecuting such enterprises through an unsettled region, in connexion with the more recent distubance of the business relations of the country by the prosecution of a great civil war have prevented any of these roads from penetrating very far toward their northern termini. The roads referred to are as follws :

1. The Grand Rapids and Indiana Railroad, running from Fort Wayne, Indiana, through the western part of the State by Grand Rapids and Little Traverse bay, and terminating at the straits of Mackinac. This road runs about 21 miles east of Traverse City, and 14 from Elk Rapids.

2. The Amboy, Lansing and Traverse Bay Railroad, beginning at Amboy, near the southern line of the State, and running by way of Lansing and Saginaw to Little Traverse bay.

3. The Flint and Pere Marquette Railway, beginning at Flint and running by way of East Saginaw to lake Michigan, at the mouth of Pere Marquette river—a point almost directly opposite Cheboygan, in Wisconsin.

The progress made in the construction of these roads is as follows :

The Grand Rapids and Indiana Road has been graded along some portions of its line, and it is promised that 20 miles will be soon completed from Grand Rapids northward. The Amboy, Lansing and Traverse Bay Railroad has been bailt a distance of 23 miles, from Lansing to Owosso.

The Flint and Pere Marquette road is completed from Flint to East Saginaw, 34 miles. A road under a distinct incorporation has been constructed from Flint to Holly, connecting the Flint and Pere Marquette with the Detroit and Milwaukie Railway at Holly, thus forming a very important line of communication from Detroit to Saginaw. It is said to be the intention of the Flint and Pere Marquette Company to extend their road beyond Saginaw through Midland City, 27 miles, during the coming year. This will carry communication well toward the Grand Traverse region, which is but 125 miles distant.

It has been very properly suggested that the western terminus of the Flint and Pere Marquette Railway ought to be changed to some point within the Grand Traverse region—as Frankfort or Traverse City. This, besides furnishing an outlet to the richest portion of the lower peninsula, would be in a direct line toward Escanaba, at the entrance of Little Bay de Noquet, from which railroad communication already exists to Marquette on Lake Superior. The distance from Escanaba is about 85 miles to Frankfort, and the same distance to Northport. By this connexion the Grand Traverse region would be accomodated, and the southern portion of the State would be furnished with a pleasant and expeditious summer route to Lake Superior.

The practicability and eminent utility of the communication indicated ought to commend it to the attention of the business interests of the State and country.

XVII. CONCLUSION.

The developement of Leelanaw county has been very materially retarded by an extensive Indian Reservation lying in the midst of an active white population. This reservation was made a few months after the first settlement of Northport. It extended from the village of Northport south to township 28, and embraced the entire county as far west as range 13 west, leaving only the small triangle north of Northport.as the sustaining back country for that village. Accordingly, though founded under the most promising auspices, a repressive—per-

haps we should say an oppressive—public act has deferred for ten years the prosperity of this important point. The term of reservation expires this year, and it is now understood that the land will be speedily brought into market. Mr. Smith, the Indian Agent, informed me that there were this year only 700 Indians to receive their annual payment of $4 each. This payment, as I had opportunity to observe, is at once transferred to the posession of the merchants and traffickers of Northport in exchange for clothing and provisions—a slight offset to the injuries sustained from the reservation. On the reservation at Little Traverse are 1,300 Indians.

A more general and even more serious obstacle to the development of the region is the withdrawal from market of the odd sections reserved for the construction of the Grand Rapids and Indiana Railroad. I found the complaints on this subject universal and emphatic. The reservations for this road cover more than one half of Grand Traverse county, and the entire region on the east side of the bay. It is but justice to the population already engaged in the development of the country, that the injuries sustained from this source should be discontinued. It may be that the only method of constructing railroads through a new country is by means of land grants; but it is obvious that in this case, the grants have not secured the end proposed, while they have proved of incalculable injury to the region in which they are located. Any continuance of these grants, and any new grants proposed to be made, should be placed under more rigorous stipulations than heretofore, with a view to securing to the regions incommoded by them a more prompt release from the injuries inflicted. The congressional grant to the Grand Rapids and Indiana and other land grant railroads in the State, expires by limitation on the 3rd. of June, 1866.*

The Homestead Act in its practical workings has also retired from occupation many thousands of acres of valuable land. Large numbers of persons, having entered their "homesteads,"

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* For the legislation respecting the Grand Rapids and Indiana Railroad see Acts of Congress approved 3d June, 1856, and 7th June, 1864; and State laws approved severally 14th Feb., 1857, 3d Feb., 1858, 14th Feb., 1859, 15th Feb., 1859, 12th Feb., 1861, 11th March, 1861, 15th March, 1861, 15th Jan., 1862, 2d Feb., 1865, 10th March, 1865.

have failed to comply with the law requiring actual residence; and they consequently remain unimproved and retired from the market, or the prescribed means must be resorted to for bringing them again into market. These means, with a view to the ample protection of the first claimant, have been made circuitous, slow and tedious. In consequence, men undertake, only in urgent cases, to secure titles to abandoned homesteads; and such lands are liable to remain a long time without improvement.

At the present time, most of the land lying near navigable water has been taken up. Receding from the shore, private claims become less and less frequent, and disappear, on the east side of Grand Traverse bay, at the distance of seven or eight miles back. In Leelanaw county we find them distributed from shore to shore, with many unoccupied lands interspersed.

The lands belonging to the general government are the even sections within the limits of the railroad grants, except so far as taken up by settlers. After the 3d of June next, the odd sections revert to the government, except in case of new legislation perpetuating the grants.

The State swamp lands within the limits of this region are scarcely worthy of mention. Those formerly held as such must be nearly exhausted in the construction of the State roads.

The reservations for the Grand Rapids and Indiana Railroad are the odd sections where not previously occupied or reserved, to the distance of "six sections in width on each side" of the road, and, where previously occupied or reserved, the odd sections beyond these limits, to any distance within 15 miles. The maps of the company represent their land grant as extending about 15 miles, throughout the entire region. This extension uses up the unsold odd sections nearly as far west as Traverse City and throughout Kalkasca and Antrim counties.

There is no Indian reservation within the region under consideration, except the one already referred to; and its limits have been indicated. Indians are seldom seen in any other portion of the region.

Notwithstanding the serious drawbacks to the development of this region, growing out of its remote situation, the erroneous ideas of its climate and soil, and the injustice which it has suf-

fered from public legislation, it has, during the past year or two, undergone a more rapid improvement than any other portion of the State. There have been entered at the Register's office in Traverse City, since January 1st, 1863, 1,422 homesteads of 160 acres each, making a total of 227,520 acres. In the same time there have been 467 cash purchases, estimated at 37,360 acres. The lands located with Military Land Wsrrants and Agricultural College Scrip are at least double the cash purchases, or about 74,720 acres, making a grand total of 339,600 acres. This land district extends from the south line of Manistee county to the straits of Mackinac, and from R. 3 W. to lake Michigan. Most of the settlement, however, is around Grand Traverse bay, from R. 8 W. to R. 15 W., and from T. 21 N. to T. 32 N. These statements were given me by the Register late in October. The entries at the office during November were 12,450 acres; of which 1,091 acres were purchased for cash, and 1,240 were located with warrants.

Beyond all controversy, the Grand Traverse region offers stronger attractions to capital and settlement than any other portion of the State or of the entire northwest. Even the mighty forest which has to be felled before the farmer can avail himself of the soil, is probably less of a detriment than an advantage. Besides insuring him an inexhaustible supply of fuel, for the labor of cutting; besides furnishing him with a merchantable commodity in the form of cord-wood, upon which he can realize for each day's work; besides protecting him and his stock and crops from the severity of the wintry blast, the forest itself is a source of food to horses and cattle, both in summer and winter. It is no uncommon occurrence, as I saw in a multitude of cases, for a settler to make his appearance late in the autumn, with little means but his muscle, an axe, a yoke of oxen and a cow. He selects a spot for his dwelling, and while he fells the trees to supply the logs for his cabin, his cow and oxen support themselves by browsing, and the milk furnished by the cow goes far toward the support of his family. Having erected his cabin, he spends his winter in chopping; and, in the mean time, his stock fatten themselves by browsing on the fallen timber, so that they actually enter the

spring in better flesh than they did the autumn. I had accounts of this kind from various sources. Mr. Fisher, of Glen Arbor, told me of a pony that escaped from his owner, and subsisted in the forest seven years before he was caught.

A more thorough system of farming is needed, which will be secured when more capital can be applied to the business. A more varied industry is needed; and this also will be introduced as wealth increases and the advantages of the region become known.

Religious and educational accommodations have kept pace with the development of the region. Traverse City, Elk Rapids, Northport and Benzonia have preaching every Sabbath—many of the settlements further back, once in two or four weeks. At Traverse City and Northport the Congregationalists and Methodists both have organizations. There are also church organizations at Monroe settlement, at Glen Arbor, at Whitewater, at Old Mission, at New Mission and some other points. Schools are maintained within reach of every neighborhood. There are at least six school houses in the township of Traverse. At Benzonia is Grand Traverse college and preparatory school.

Access to the Grand Traverse region is had by propellers from any of the lake ports. The numerous propellers all stop somewhere within the limits of the region; and, by inquiry, it can be ascertained at what point any particular propeller is in the habit of stopping. Those wishing to reach the bay had better not take passage for Glen Arbor or Carp river [Leland,] and those wishing to reach the latter places had better not take passage to the bay. Passengers are landed at Northport two or three times a week; and from there they can proceed on the Sunnyside to any other point on the bay. The Alleghany runs once a week directly from Chicago to Northport and Traverse City.

Visitors are cautioned against allowing steamboat captains to persuade them to be landed on the Manitou islands—a frequent wooding place—since great difficulty is often experienced in getting from there to the main land.

ERRATUM.—Page 32, foot note, for "Lenawee" read "Leelanaw,"

APPENDIX

TO A REPORT ON THE GRAND TRAVERSE REGION.

By A. WINCHELL.

Paleontological investigations made since the printing of the body of this Report, enable me to present a more satisfactory account of the Hamilton group of Little Traverse bay than has hitherto been done. This region possesses considerable geological interest, in consequence of being removed at least 250 miles in a straight line from the nearest Hamilton rocks, (at Widder, C. W.,) which have heretofore received the attention of paleontologists.

To co-ordinate the various outcrops along the shore of the bay and lake, as far as the black shale beds, is a problem of no little difficulty, since the shore-line runs nearly in the strike of the strata, and the latter present numerous irregular undulations, and undergo, moreover, considerable lithological changes in short distances. By fixing upon certain obvious paleontological horizons, however, and parallelizing strata which are obviously synchronous, all the various localities and strata fall by degrees into their proper places.

In default of a diagram, I have arranged the following table to exhibit to the eye the stratigraphical relations of the several localities. The term "Tropidoleptus Beds" is changed to "Bryozoa Beds," since the supposed *Tropidoleptus* proves to be a *Strophodonta*. A "Pleurotomaria Bed," well marked, is also recognized at the bottom of the series. The letters correspond with those in the sections given in the body of the Report. The full-face capitals indicate the strata most readily identifiable.

STRATIGRAPHICAL RELATIONS OF THE LOCALITIES.

	855	856	857	858	861	862	863	865	880	881	884
Chert Beds...............	...	...	...	...	...	...	...	...	...	...	**E** **D** C B A
Buff Magnesian Beds......	...	...	...	...	...	...	...	**E** **D** **C**	...	...	...
Acervularia Beds...........	...	...	E D G	**B** A	D C **B** A	C **B** A	**B** A	B **A**	D **C**	**A**	O
Bryozoa Beds.............	...	...	B **A**	...	...	...	...	...	**B** A	...	...
Stromatopora Beds.........	...	D **C**	...	...	...	...	...	...	...	...	...
Pleurotomaria Bed.........	B **C** B A	**B** **A**	...	...	...	...	...	...	...	...	...

The table which follows embraces a list of all the fossils thus far collected, including the collections of my recent survey and those heretofore made by State authority. The five succeeding columns of the table show the vertical distribution of the species through the beds.

DISTRIBUTION OF THE SPECIES.

CATALOGUE.	*Pleurotomaria Bed.*	*Stromatopora Beds.*	*Bryozoa Beds.*	*Acervularia Beds.*	*Magnesian Beds.*
Fistulipora labiosa *Win*.				*	
" Saffordi *Win*.			*	*	
Callopora punctillata *Win*.			*	*	
Favosites Alpenensis *Win*.			*	*	*
" nitella *Win*.			*	*	
" dumosa *Win*.	*	*			
Lunatipora Michiganensis *Win*.	*				
Alveolites strigillata *Win*.				*	*
" megastoma *Win*.				*	
" n. sp?		*			
Chætetes Hamiltonensis *Win*.				*	
" microscopica *Win*.			*	?	
Syringopora fenestrata *Win*.				*	
" alectiformis *Win*.				*	
" crassata *Win*.					*
Zaphrentis Traversenis *Win*.	*	*	*	*	
" cystica *Win*.				*	
Cyathophyllum simplex? *Hall*.				*	
" panicum *Win*.		*			
" ? partitum *Win*.			*		
" sp?					*
Heliophyllum Halli *E. & H*.	*				
" tenuiseptatnm *Bill*.			?	*	
Acervularia Davidsoni *E. & H*.			*	*	
Phillipsastræa Verneuili *E. & H*.			*		
Cystiphyllum Americanum *E. & H*.				*	
Stromatopora monticulifera *Win*.		*		*	
" pustulifera *Win*.		*			
" nux *Win*.		*			
" cæspitosa *Win*.		*			
Aulopora serpuloides *Win*.				*	
" aperta *Win*.			*	*	
" conferta *Win*.				*	
" cyclopora *Win*.				*	
Tentaculites subtilis *Win*.			*		
Fenestella eximia *Win*.				*	
" filitexta *Win*.			*		
Stictopora sulcata *Win*.			*		
Crania radicans *Win*.				*	
" crenistria *Hall*.				*	
" (Pseudocrania) anomala *Win*				*	
Chonetes Emmetensis *Win*.			*		
Strophodonta inæquistriata *Con*.				*	
" subdemissa *Hall*.			*	*	
" erratica *Win*. (3 Vars.)	*	*	*	*	
" imitata *Win*.				*	
" ampla (*Hall*) *Bill*.			*		
" cincta *Win*.			*		

DISTRIBUTION OF THE SPECIES.—*Continued.*

CATALOGUE.	*Pleurotomaria Bed.*	*Stromatopora Beds.*	*Bryozoa Beds.*	*Acervularia Beds.*	*Magnesian Beds.*
Strophodonta nacrea *Hall*			*		
Cyrtia Hamiltonensis *Hall*	*	*	*	*	
Spirifera Clintoni *Hall*			*	*	
" subattenata *Hall*				*	
" bidorsalis *Win*				*	
" mucronata *Con*			*		
" pennata (*Owen*) *Hall*			*		
" consors *Win*	*	*			
" filitexta *Win*		*			
Martinia athyroides *Win*	*				
Spirigera concentrica *Bronn*		*	*	*	*
" eborea *Win*			*		
Merista lens *Win*	*	*			
Trematospira ? liniuscula *Win*		*			
Atrypa reticularis *Dal*	*	*	*	*	
Pentamerus occidentalis *Hall*		*		*	
" intralineatus *Win*			*		
Leiorhynchus sesquiplicatus *Win*			*		
Terebratula Linklæni *Hall*				*	
" Traversensis *Win*	*	*	*	*	
Pterinea decussata *Hall sp*			*		
Aviculopecten intercostalis *Win*			*		
Sanguinolites (Grammysia ?) sulcifer *Win*				*	
Lucina ? Hamiltonensis *Win*			*		
Conocardium Emmetense *Win*			*	?	
" bifarium *Win*		*			
Edmondia ? ledoides *Win*	*				*
" mactroides *Win*	*				*
Nuculites oblonga ? *Hall*			*		
Pleurotomaria mucro *Win*					*
" cavumbilicata *Win*	*				
" Emmetensis *Win*	*				
" parvispira *Win*	*				
Orthoceras exile ? *Hall*	*		*		
" pustulosum *Win*			*		
" sp ?	*				
Gomphoceras omicron *Win*				*	
Spirorbis omphalodes *Goldf*			*	*	
" ammon *Win*				*	
" obesa *Win*				*	
Phacops rana *Green*	*	*	*	*	
Dalmania Boothi *Hall*				*	
Fish Bones	*				
Cycliferous Ganoid Scale			*		

The group contains also an undetermined *Taeniopteris* and a *Lichenalia*.

The following digest of the foregoing table sets forth the paleontological grounds of the distinction into different beds.

	Total Species.	*Restricted.*	*In two Beds.*	*In three Beds.*	*In more than three.*
Magnesian Beds..................	8	3	3	1	1
Acervularia Beds.................	46	24	14	2	6
Bryozoa Beds.....................	41	21	12	1	7
Stromatopora Beds................	21	9	5	1	6
Pleurotomaria Bed................	20	8	6	1	5

The Acervularia and Bryozoa Beds, while each holds more than 50 per cent. of species not ranging beyond it, contain 19 species, or 28 per cent. of the whole, in common. Lithologically they may be described as a series of dark, bituminous limestones and shales; and in the general facies of the formation, they present themselves structurally as one mass. Below this mass is another of strikingly different aspect, composed of pale buff, massive limestones, with little shaly or bituminous matter, in which I have distinguished the Stromatopora and Pleurotomaria Beds; which, while each holds about 38 per cent. of peculiar species, contain at the same time 9 species, or about 20 per cent. of the whole, in common. Above the Acervularia Beds we find another physical change in the Magnesian Beds. These are dark-buff, coarse, rough, vesicular, with few fossils. Of these, 3 or 38 per cent. are peculiar; 2 are species which have too wide a vertical range for use in stratigraphical determinations, and 2 are singularly identified with species in the bottom of the formation. The Chert Beds present another set of physical characters; though I suspect the amount of Chert is very variable.

I would suggest then, as the most obvious and tenable method of grouping the strata, the following:

IV. Chert Beds.
III. Buff, vesicular Magnesian Limemstones.
II. Bituminous Shales and Limestones. { Acervularia Beds. Bryozoa Beds.
I. Pale-buff, massive Limestones. { Stromatopora Beds. Pleurotomaria Beds.

This grouping of the strata will hold good, I think, throughout the State, and perhaps in other regions. Judging from the fossils, the Acervularia Beds outcrop at Iowa City, and the Bryozoa Beds at New Buffalo, in Iowa. On the eastern side of the peninsula of Michigan, the rocks with *Stromatopora* are seen to be succeeded downwards by the recognized Corniferous limestone. Indeed, the two are here, as in lake Erie, but one mass, physically.

DIAGNOSES OF NEW SPECIES.

Fistulipora labiosa.—Incrusting in thin layers; the delicate cell-mouths surrounded by distinctly elevated and tumid lips; intercellular surface smooth; intercellular tissue consisting of minute polyhedral vesicles—a radiating series often surrounding the minutely septate cells. Intercellular distances .33 mm. (.013)*; diameter of cell-mouths .381 mm. (.015); distance of septa .102 mm. (.004).

Fistulipora Saffordi.—Incrusting in thin layers; cell-mouths scarcely elevated, without thick lips; intercellular surface generally exposing the minutely vesicular tissue; vesicules often radially disposed around the cells. Intercellular distances .254 mm. (.01); diameter of cell-mouths from .355 mm. (.014) to .508 mm. (.020).

Callopora punctillata.—Delicate incrustations; cells approximate, but cylindrical or compressed-cylindrical—occasionally crowded and sub-prismatic; intercellular structure minutely vesicular, or, in places, wanting. Intercellular distances .127 mm. (.005) or less; diameter of cell-mouths .152 mm. (.006).

Favosites Alpenensis.—Related to *Calamopora polymorpha* Goldf. Always massive; mural pores arranged in one (sometimes two) irregularly or scarcely lineal series on each side—their margins indented instead of raised. Walls distinctly double, quite smooth; septa extremely thin. Cells smaller and pores more numerous than in *F. Billingsi* Rominger. Distance of pores 2.286 mm. (.09); of septa 1.270 mm. (.05).

* Measurements in millimetres. Numbers in parenthesis are equivalents in inches.

* I think III & IV are the equivalents of ... I

Favosites nitella.—Related to *C. spongites*, var. *ramosa* Goldf. In small masses varying from globoid to elongate or scarcely branching. Cells sub-circular, sub-equal, with a few minute interstitial ones. Septa distinct, irregular, complete or incomplete; pores scattered, indented around the orifices. Distance of pores .76 mm. (.03); diameter of largest cells .76 mm. Occurs also at Iowa City.

Favosites dumosa.—Resembles *F. Alpenensis* in size and form of cells and cell-mouths, and in size and arrangement of pores, but differs in much more crowded and thicker septa, and in growing in stout, thickly-clustered branches. Distance of septa .51 mm. (.02).

Lunatipora (New Genus).—Massive, or with branches consolidated; cells elongate, radiately ascending and curving outwards from an imaginary flexuous axis, compressed, their transverse section bounded by two or three segments of circles, often sub-crescentic; walls apparently double, but not separable (?); destitute of communicating pores as far as known; interior with transverse diaphragms. Cell-mouths not seen.

Differs from *Favosites* and *Chœtetes* in the form of the cells, and from the former in the probable absence of pores; from *Alveolites* and *Cladopora* in the great length of the cell-tubes, and from the latter in the presence of distinct diaphragms, and a more massive form.

Lunatipora Michiganensis.—Cells small, much flattened; diaphragms rather remote, complete or incomplete, often oblique. Longer diameter of larger cells 1.55 mm. (.06) to 2.03 mm. (.08); shorter diameter .51 mm. (.02).

Alveolites strigillata.—Somewhat ramose; cell-mouths crowded; transverse section at aperture double-convex; outer lip slightly elevated in the middle—often with a narrow rim either inflected or reflected; inner side of aperture marked by 10–15 delicate striæ, which diverge and extend over the outer lip of the contiguous cells above. Transverse diameter of cell-mouths 1.27 mm. (.05); distances apart longitudinally 1.02 mm. (.04).

Alveolites megastoma.—Thin incrustations, with large, crowded, obliqe cell-mouths which have the form of a segment of a circle in transverse section; outer lip, when perfect, lying in a plane normal to the general surface, its exterior marked by minute distinct transverse lines of growth; radial striæ very obscure. Transverse diameter of cell-mouths .28 mm. (.11); distances apart longitudinally, the same.

Chætetes Hamiltonensis.—Incrusting, or in solid tubercular masses or stems, with crowded, prismatic tubes .25 mm. (.01) in diameter, diverging in all directions at right angles with the main axis; cell-walls simple; septa complete .25 mm.

(.01) to .51 mm. (.02) apart. A similar Canadian species has larger tubes and spinuliferous cell-mouths.

CHÆTETES MICROSCOPICA.——Generally small, cylindrical, solid branches, formed of radiately ascending and curving, crowded, polygonal non-septate tubes. Diameter of cell-mouths .28 mm. (.011).

SYRINGOPORA FENESTRATA.—Habit and characters similar to the following, but smaller. The young somewhat resemble *Aulopora tubæformis* Hall (not Goldf.) Diameter of tubes 2.29 mm. (.11). Occurs also in the Hamilton of C. W.

SYRINGOPORA ALECTIFORMIS.— Tubes large, loosely and confusedly aggregated, prostrate or declined, adhering to other corals, in the young state auloporiform; exterior smooth or faintly wrinkled; interior feebly striate. Diameter of tubes 4.06 mm. (.16) to 5.84 mm. (.23).

SYRINGOPORA CRASSATA.—Tubes of medium or moderate size, very geniculate and confused, externally much wrinkled transversely; irregularly constricted, often compressed; tube-walls unusually thick—the central cavity often nearly obliterated. Diameter of tubes 1.52 mm. (.06) to 2.03 mm. (.08).

ZAPHRENTIS TRAVERSENSIS.—Fossette rudimentary. Differs from *Cyathophyllum simplex* Hall in its more abundant epitheca, less contorted lamellæ, its finely vesicular outer zone, and its more elongated and erect form. Often attached obliquely.

ZAPHRENTIS CYSTICA.—Outer zone of finely vesicular tissue reaching nearly half way to the center; central septa very thin and irregular; lamellæ about 60, of which half terminate with the vesicular zone.

CYATHOPHYLLUM PANICUM.—Having the form and size (or somewhat smaller) of detached stems of *Diphyphyllum Archiaci* Billings, but without the double wall. Resembles *C. cæspitosum* (Goldf.) E. & H., but is more delicate and more straggling.

CYATHOPHYLLUM? PARTITUM.—Tubes small, branching; walls thick, without radial lamellæ or visible striæ; internal cavity divided by irregularly disposed vertical partitions, which, in transverse sections, describe the chord (instead of radius) of a circle; space inclosed between the lamellæ and walls transversely and minutely septate. The same structure extends into the branches. Epitheca slightly wrinkled. Diameter of tubes 7.62 mm. (.3). Scarcely conforms to any established genus.

STROMATOPORA PUSTULIFERA.—In very large, spheroidal, ovoid or elongate masses, composed of arching, transverse layers, formed of laminæ of coralline substance separated by a network of minute passages which, at intervals, coalesce and turn upwards through the layer, radiating and ramifying again on its upper side. The places where the layers are thus trav-

ersed are raised on the upper side into little eminences. The distinction of layers is produced by variations in the density of the coralline substance. Masses of coral several feet in diameter; distance of pustules 4.06 mm. (.16); mean thickness of laminæ .20 mm. (.008). Occurs also at Iowa City.

Stromatopora monticulifera.—In very large spheroidal masses constituted like those of *S. pustulifera*, but differing therefrom in the much larger and more remote eminences on the upper surfaces of the concentric beds, and in the larger and more distinctly radiate character of the passages which diverge from the apices of the monticules. These passages, on the exposed surface, are little flexuous, somewhat branching channels which diminish in size and disappear within 5 mm. (.2). Distance of monticules .76 mm. (.3) to 10.2 mm. (.4). Attains a diameter of at least 3.5 metres (12 ft.)

Stromatopora nux.—In small, spheroidal, sometimes contiguous and coalesced masses, formed, unlike the foregoing species, by accretions on all sides. External surfaces of layers not pustulose. Masses occur from 25 mm. to 125 mm. in greater diameter. A species apparently the same occurs on Kelly's Island, lake Erie.

Stromatopora cæspitosa.—In general form resembling a large, cæspitosely branching, cyathophylloid coral; stems externally in contact or more than 25 mm. distant. A longitudinal section shows the characteristic layers arching across the stem and resembling *S. pustulifera* in miniature; a transverse section exhibits radiating lamellæ as in Cyathophyllidæ, but there is no outer wall, and the interior is completely filled with concentric circles of coralline substance, except a small perforation in the center. Mural system entirely wanting, as in other Stromatoporæ; exterior of stem longitudinally triate. Diameter of stems 4.5 mm. (.18) to 7.6 mm. (.30). Occurs in masses two or three feet in diameter.

This remarkable species exhibits a transition from *Stromatopora* to *Cyathophyllum* and might well form the type of a new genus.

Aulopora serpuloides.—Tubes minute, long, cylindrical, sinuous; di-or trichotomously stoloniferous, often superimposed; cell-mouths circular or compressed, generally opening upwards, not salient. Diameter of tubes .25 mm. (.01); length often 1.78 mm. (.07).

Aulopora aperta.—Tubes short, often extended in double or triple linear series; cell-mouths not elevated, generally not limited on the lower or posterior side, leaving the whole length of the tube open. Diameter of tubes 1.27 mm. (.05).

Aulopora conferta.—Tubes small, compressed, crowded, forming an incrustation; cell-mouths slightly elevated, circular, erect, sub-equally distributed, presenting a remote resemblance to a *Fistulipora*. Mean distances of cell-mouths 1.78 mm.

(.07); diameter of cell-mouths .64 mm. (.015.) Resembles *A. conglomerata* Goldf., but more consolidated.

AULOPORA CYCLOPORA.—Tubes rather long, arranged in single linear series which branch without anastomosing; cell-mouths oblique, not elevated. Length of tubes 2.29 mm. (.09) to 3.56 mm. (.14); diameter of cell-mouths 1 mm. (.04).

TENTACULITES SUBTILIS.—Minute, extremely slender, very gradually tapering; rings regular, rounded. In a terminal fragment 3.81 mm. (.15) long, the whole number of rings is 40; mean distance apart on apical third .064 mm. (.0025). Longest specimen 12.7 mm.

FENESTELLA EXIMIA.—Rays angulated along the middle, bearing two rows of pores with salient margins, opening obliquely; 23 pores in the distance of ten fenestrules. Length of fenestrules .51 mm. (.02); breadth .37 mm. (.015.) This species and one similar to the preceding occur at New Buffalo, Iowa.

FENESTELLA FILITEXTA.— Rays extremely delicate, obtusely carinated; fenestrules comparatively large and cells remote. Non-celluliferous side minutely striate. Length of fenestrules 2.03 mm. (.08); breadth .76 mm. (.03); diameter of ray .25 mm. (.01); distance of cells .18 mm. (.007); longer diameter of cells .08 mm. (.003).

STICTOPORA SULCATA.—Small, compressed, solid, ancipital, dichotomous stems, celluliferous on both sides; cells oval, with salient lips, arranged in 6–9 longitudinal series separated by prominent rigid striæ (in one variety little developed). Greater diameter of stem 2.29 mm. (.09); less diameter .89 mm. (.035); distance between cells .2 mm. (.009); greater diameter of cells .15 mm. (.006); less diameter .1 mm. (.004.) Seven cells in 2.5 mm. (1).

CRANIA RADICANS.—Attached valve very irregular, with distinct cardinal truncation, always presenting the appearance of area, triangular fissure and cardinal processes; central portion of valve often absorbed or wanting, leaving only the upturned border. Exterior furnished with radiciform, flexuous often bifurcate, hollow spines or appendages, sometimes as long as the shell. Diameter about 3.8 mm. (.15).

CRANIA (PSEUDOCRANIA) ANOMALA.—Shell free or attached, irregular, thick; hinge line nearly equal to greatest width. Ventral valve with three or four pairs of muscular impressions, a broad, striated area, arched false deltidium nearly filling the very broad triangular fissure and fusing with cardinal processes to form a spoon-shaped orthidoid appendage. Exterior with many fine radial striæ. Transverse diameter 28 mm. (1.1); length 20 mm. (.8).

CHONETES EMMETENSIS.—Small, semicircular; hinge-line equal to greatest width, or slightly greater or less, armed with two short spines near each extremity, which turn out at right

angles to axis of shell, and a minute tubercle near the beak. Dorsal valve very concave. Area wide, formed equally from both valves, turned over into the plane of the shell, slightly hollowed. Triangular foramen occupied by dental process. Ribs 10 or 11 around the margin, stout, convex, simple or with two or three bifurcated ones. Concentric striæ sometimes conspicuous.

Resembles *C. gibbosa* Hall and *C. Koninckana* N. & P. in the direction of its spines, but differs from these and related species in the small number of its ribs.

STROPHODONTA ERRATICA.—Resembles *S. arcuata* Hall in hinge structure, but central cardinal process of ventral valve is narrower, and dental lamellæ denticulated. Divaricator scars drawn to a point on median line; hinge-line abruptly acuminate. Ribs few and large on the umbo, increasing by implantation, and diminishing in size toward the margin. In variety *solidicosta*, about 9 large nearly undivided ribs; in variety *fissicosta*, ribs fimbriated till they number 50 to 80 around the margin. The last variety, except in the ears, resembles *S. subdemissa* Hall. Comp. also with *S. plicata* Hall, (XIII Reg. Rep., *p.* 90) and *S? costata* Owen, (Surv. Wis. Minn. & Io., Tab. III, Fig. 11).

STROPHODONTA IMITATA.—Adductor bosses prominent, bicrescentic, with a short, stout, median ridge issuing from between them forwards. Otherwise resembles S. *inæquistriata*, except that the striæ are nearly equal, and the shell is relatively shorter and only 12.7 mm. (.5) to 17.8 mm. (.7) broad.

STROPHODONTA CINCTA.—Size and general appearance of *S. inæquistriata*. Hinge-line less than greatest width. hinge-angles rounded. Inside of ventral valve minutely pustulose in all parts, and marked by a prominent ridge all around near the border. Divaricator scars diverging, reaching two-thirds the distance to the anterior border; retractor scars nearly as long.

SPIRIFERA BIDORSALIS.—Resembles *S. biplicata* and *bimesialis*, but is not produced at hinge extremities; has a high incurved ventral beak, and delicate, regular imbricating lamellæ. Length 8.88 mm. (.35); breadth 12.7 mm. (.5). Very commonly parasitic on corals.

SPIRIFERA CONSORS.—Semicircular, with salient hinge extremities, ventricose to the margin. Dorsal valve with little elevated but strongly isolated fold, having a median furrow throughout its whole length; ventral, most ventricose, especially near the incurved beak; having a broad, sharply-rounded, well-defined sinus reaching to the beak and destitute of a median ridge. Dorsal area narrow; ventral elevated, arched and perforated by a triangular opening half as broad as high. Surface with about seven rounded plications each side of the middle, and crossed by feeble lines of growth.

Length 11.68 mm. (.46); breadth 21.6 mm. (.85); depth of both valves 11.22 mm. (44).

Less mucronate, more ventricose, and with fewer plications than *S. subattenuata varicosa* and *bimesialis*. Much more ventricose than *S. bidorsalis*. Apparently identical with an undescribed species from Columbus, Ohio.

Spirifera filicosta.—Form and two-thirds the size of *S. Parryana* Hall. Fold and sinus much less pronounced and, with the fewer plications, marked by numerous radial striæ. Ventral beak much incurved; area not well defined.

Martinia athyroides.—Triangularly terebratuliform, without fold or sinus. Ventral valve nearly twice as deep as the other, with a projecting, somewhat incurved beak. No true area, but a broad, triangular fissure extends to the apex of the beak. Shell-structure thin-lamellar—neither punctate nor fibrous. Incremental surface markings numerous, fine, regular. Length 14.22 mm. (.56); breadth 13.21 mm. (.52). Resembles *Charionella Circe* Billings, from Corniferous limestone, but the beak is not perforate.

Spirigera eborea.—General appearance of small specimens of *S. concentrica*, but more ventricose, with a fuller and more produced ventral beak. Shell substance extremely solid and ivory-like, but not punctate; surface polished, with numerous extremely delicate concentric striæ. Length 9.4 mm. (.37); breadth 9.14 mm. (.36); depth of ventral valve 4.06 mm. (.16).

Merista lens.—Quadrate-rotund, lenticular, both valves equally convex, the ventral having the beak closely incurved over its opposite. Ventral sinus only represented by a slight anterior projection; dorsal fold only a broad angulation of the valve, except anteriorly. Surface of casts marked by six narrow, remote, radiating ridges around the middle of each valve, bifurcated nearer the margin, (vascular markings?) Occlusor scars ligulate, deep. Shell thick, fibrous. Spires present. Length and breadth 19.81 mm. (.78).

Trematospira? liniuscula.—Form and size of *T. perforata* Hall. Cast with numerous faint radiating lines. Ventral beak incurved, apparently imperforate. Dental lamellæ two-fifths the length of the valve. Occlusor scars oval, deep. Dorsal valve with a transverse narrow area; false area of ventral valve with a triangular fissure extending to the beak. Fold and sinus reaching the beak, but very feeble.

Pentamerus intralineatus.—Size of *P. occidentalis* Hall, but broader and more regularly (though faintly) costate on the anterior two-thirds, with shallow ventral sinus reaching to beak. Shell-fibres arranged concentrically. Exterior with numerous wavy, sub-lamellose, concentric grooves, and fine intervening striæ; interior with numerous fine, radiating, grooved striæ.

LEIORHYNCHUS SESQUIPLICATUS.—Shell having the form of *Spirigera concentrica*, with a more abrupt sinus and fold which, with the faint plications, extend only half way to the beak. About four plications on the fold, and as many on each side. Concentric lines fine and indistinct. Length 8.38 mm. (.33); breadth 9.65 mm. (.38).

TEREBRATULA TRAVERSENSIS.—In form resembling *T. Linklœni* Hall, but broader, with more of a false area on ventral valve, and no trace of sinus. Surface, also, sub-lamellosely striate concentrically, and pores larger, more oval and more remote—their two diameters and their distances being as 4: 7: 6, while in *T. Linklœni* the same dimensions are as 3: 4: 4. Smaller diameter of pores .0321 mm. (.00126); greater .0559 mm. (.00220); the intervening distance from end to nearest end of pore .048 mm. (.00189.) In *T. Linklœni* these dimensions are .0213 mm. (.00084), .0321 mm. (.00126) and .0359 mm. (.00141).

AVICULOPECTEN INTERCOSTALIS.—Nearly circular in outline, compressed; anterior ear (of left valve) large, depressed-convex, strongly isolated; posterior ear small; surface (of cast) with about 36 distinct, rigid, neatly defined ribs alternated with the same number of feebler rays terminating in the middle of the shell; posterior ear and slope feebly costate; anterior ear strongly so; whole surface with fine concentric striæ, stronger on the anterior ear. Length and height 21.6 mm. (.85).

SANGUINOLITES (GRAMMYSIA?) SULCIFER.—Small, gibbous, oblong; beak sub-terminal, incurved, overhanging a deep lunule; pallial border straight or broadly sinuate; umbonal ridge sub-angulated; surface with 16–20 deep sulci separated by thin lamelliform, non-imbricated leaves. Length of medium specimen 7.62 mm. (.3); height 5.08 mm. (.2); thickness of both valves 3.56 mm. (.14).

LUCINA? HAMILTONENSIS.—Shell small, circular, appressed; beaks central, small, scarcely exceeding the hinge-line, turned forward. Exterior with 8–10 deep, broad concentric furrows on the body of the shell, and numerous concentric striæ. Length 15.24 mm. (.6); height 13.97 mm. (.55). Smaller, less gibbous and more deeply and broadly sulcated than *L? proavia.*

CONOCARDIUM EMMETENSE.—Abruptly truncate anteriorly, conical posteriorly, constricted behind the beaks, gibbous, ornamented with about a dozen strong ribs, which are cancellated by finer and more numerous concentric striæ—the three ribs on the angle of the truncation stronger than the others. Differs from *C. eboraceum* Hall in the much greater relative relative strength of the ribs.

CONOCARDIUM BIFARIUM.—Small; body of shell rising into a ventricose ridge running nearly at right angles with hinge,

with a deep constriction on each side—deepest on rostral side; whole surface costate with rounded ribs which are largest on the rostrate slope of umbonal swell; inside of shell marked by square ribs corresponding to the intervals between the external ones. Exterior also with fine concentric striæ.

EDMONDIA? LEDOIDES.—Elongate-ovate, ventricose, slightly narrowed and appressed posteriorly; ventral margin distinctly but not strongly curved, hinge margin slightly so; beak subterminal, little projecting. Casts with a faint fold running from beneath the beak to the postero-ventral region. Cardinal processes (teeth?) consisting of one stout and triangular under beak of left valve, and two smaller ones in right valve. Each valve has also a pair of slender divergent lamellar teeth (perhaps "cartilage supports,") exterior to the cardinal ones. Length 25.4 mm. (1.); height 12.19 mm. (.48).

EDMONDIA MACTROIDES.—Hinge structure and principal characters like *E. ledoides*, but shorter, more ventricose, rounded on ventral side, sometimes sub-angulated along anterior and posterior unbonal slopes—especially in old specimens. Anterior and posterior muscular pits rather deep, round-oval, near the beak. Commissure deeply indented anteriorly, beneath the beaks. Exterior marked only by faint lines of growth. Length 14.22 mm. (.56); length of anterior end 4.83 mm. (.19); height 11.17 mm. [.44]; convexity of both valves 9.65 mm. [.38]. Longest specimen 30.48 mm. [1.2].

MURCHISONIA MUCRO.—Small, turreted, of 6–8 rounded whorls isolated by a deep suture, and marked by a relatively broad, raised, bicarinate band along the middle; lip slightly effuse anteriorly; umbilicus small. Height 5.08 mm. [.2]; diameter of base 2.03 mm. [.08].

PLEUROTOMARIA CAVUMBILICATA.— Rather large, deeply and broadly umbilicate, depressed conical, nearly twice as broad as high; whorls 5–6, with subcircular section, the later ones flattened above, suture impressed; exterior of whorls with obliquely transverse lines which, in the umbilical cavity, and sometimes on the base, coalesce into strong ridges. Interior smooth; two or three of the apical whorls often regularly septate. Height 23.88 mm. [.94]; diameter of last whorl 38.61 mm. [1.52].

PLEUROTOMARIA EMMETENSIS.—Higher than broad; whorls 6 to 8, all rounded, marked by a faint median, revolving, narrow band, and fine, transverse, sigmoid striæ. Cast smooth. Height 28.45 mm. [1.12]; diameter of last whorl 22.61 mm. [.89].

PLEUROTOMARIA PARVISPIRA.—Small, depressed; whorls 4 to 5, rapidly enlarging, biangulated, the flattened upper surface at right angles with the flat peripheral, and with the axis of the shell. Surface with faint sigmoid transverse striæ. Height

7.37 mm. [.29]; height of last whorl 6.84 mm. [.23]; diameter of base 9.91 mm. [.39].

ORTHOCERAS PUSTULOSUM.—Characterized by having the exterior covered with pustules of varying sizes and unequally distributed.

GOMPHOCERAS OMICRON.—Rather large, compressed-ovate, abruptly constricted at aperture; septa about 12—the last at largest diameter of shell—their distances increasing from 4.57 mm. [.18] near apex to 8.13 mm. [.32] next to last chamber. Siphon large, sub-marginal. Length about 127 mm. [5.]; greater diameter about 76 mm. [3].; smaller 63 mm. [2.5].

SPIRORBIS AMMON.—Aspect and size of *S. omphalodes* Goldf., but more strictly planorbiform, has uniformly one more whorl, and is less rapidly enlarged.

SPIRORBIS OBESA.—Three or four times the diameter of *S. omphalodes*, consisting of two or three rapidly enlarging, nearly planorboid whorls.

The foregoing is a summary of all that is at present known of the rocks of the Hamilton group on the western side of the lower peninsula of Michigan.

ANN ARBOR, 31 July, 1866.

From A. Winchell

MAN THE LAST TERM

OF THE

ORGANIC SERIES.

BY ALEXANDER WINCHELL, A. M.,

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MAN THE LAST TERM

OF

THE ORGANIC SERIES.

It is the opinion of the Christian world that our earth has been fitted up with a reference to subserving the wants of the human race; and that man is destined to remain in possession of it till the termination of the present order of terrestrial affairs. No one who has devoted a slight degree of study to the indications of beneficent and anticipatory design in nature, and especially to the prospective provisions introduced into the geological preparation of the earth for the uses of man, can entertain a rational doubt that the first part of this opinion is justified by the rigorous inductions of science. Since, however, man has been preceded in the possession of the earth by numerous tribes of lower animals, following each other in a somewhat regularly ascending gradation, up to man, the inquiry naturally arises whether the present dominant type is not destined to be succeeded by some other form of organic existence more exalted still. Does science sustain the opinion of the Christian world also, in this particular? We think it does.

I. *All geological preparations and ideas converge in man.* The world seems to have been designed with a view of stimulating to activity the powers of a thinking being. The universe is a rational product; and every department of it, and every isolated object sustains an intelligible relation to other parts and objects. We are not left to infer, or even to know, that intelligent design is locked up in the secret plans

of creatio n; bnt, what is more suggestive, as well as more satisfactory, is the fact that much of this intelligence is patent before our eyes; so that we read, as it were, a revelation of the thought embodied in the works of the visible universe. And much of that which is not manifest yields to investigation; while a stimulus to investigation is found in the hints and suggestions which nature seems intentionally to have dr opped all along the pathway of him who observes and thinks. Not only were these germs of thought planted from time to time during the whole progress of the past creation; and, not only is man the first creature capable of responding to these stimuli to mental activity, but more; this mentality, while it differs qualitatively from the highest endowments of the lower animals, is, in itself the highest possible grade of endowments. It is qualitatively identical with that infinite intelligence whose presence and supremacy are recognized throughout the universe. It is a fair presumption that when the course of animalization has attained the point toward which all these intellectual adaptations converge, a limit is reached which will not be passed except under a different general scheme.

Similar remarks apply to the co-ordination existing between the material world and the idea of the beautiful in man. The beauty and sublimity of nature have no relation to any other creature. Man is the consummation of a dualism. While the beautiful implies man, it excludes his successor. No endowment beyond or higher than a response to the provisions of nature is possible.

The beneficent provisions of the earth's crust not only prophesy man, but they reach their finality in man. It was only for human uses that the coal was treasured in the recesses of the earth; for human uses alone the mountains have lifted up their burdens of iron; for human uses only the grandest movements of geological history elaborated and distributed a soil. It is only for man that the forests yield their abundant supplies of timber and fuel. For man the edible and medicinal vegetables were provided. For man the natures of the

domestic animals were moulded; and their domestic attachments are directed to no other being.

The last geological revolution produced results of a general rather than a local character. During the Paleozoic, Mesozoic, and earlier Cenozoic ages, the action of geological agencies had been especially developed along belts parallel to the main bodies of land. In the glacial epoch, however, a phenomenon occurred which, so far as we know, was unprecedented in its universality. The whole northern portion of both continents was covered by glaciers whose effects were felt, in America, to the Ohio river; and whose *debris* were borne, in the next epoch, even to the Gulf of Mexico. This sudden extension of the range of geological activity was something paralleled by the release of the human species from those restraints which confined all preceding animals within narrow limits; and constituted, like that, an indication that a full pause had been reached in continental preparations, as when the statuary, after having developed singly, with time and care, the individual features of his work, subjects it finally to that general treatment which imparts the smooth and finished surface.

Lastly, it may be added that vertebrate development both points toward man and attains its consummation in man. The earliest fish which moved in the waters of the paleozoic seas embodied, in its osteological organization, a prophesy of man; the mesozoic reptile still pointed onward toward man; the Tertiary monkeys were a higher summit of vertebrate organization from which the higher Alp of human structure was still pointed to, illumined by the rising dawn of the modern world. In the skeleton of man we have, at last, the fulfillment of the prophesies of ages.

Man stands in the focus of all the conceptions embodied in past history. We are as little authorized to allow that the course of development is destined to advance beyond him, as to deny that it has furnished intimations in all ages, that it was destined to reach to him.

II. *Man's superiority over the brutes.* Amongst the myriads of animals which populated the earth during the cycles of geological history, supremacy was the reward only of superior force. Man gains supremacy through his intellect. Brutes dominate through the physical forces belonging to matter; man through the immaterial forces which are the attributes of Deity.

The chasm which separates the intelligence of man from that of the brutes is broad. It is not simply a step in the easy gradations observed among the brutes themselves. Even if not qualitatively superior to that of brutes, its sudden expansion is so great that its sphere of activity creates a new quality in the being. Man is the first being in all the history of the world that could contemplate creation, and abstract the intelligence displayed in it, and experience a glow of satisfaction in attaining to the thoughts first conceived in the mind of the Omniscient. Man is the first animal capable of contemplating Deity. In these exalted endowments not only does he excel the brutes, but he excels them in so vast a degree as to suggest the belief that the gradations of animal existence had been concluded, and nature had reached a full pause. The material part — the frame-work — of animality had been perfected by slow gradations; and now, on the creation of man, nature superadded an unprecedented endowment — a spiritual organization which makes man both a prince and a master-piece in creation.

When we speak of man's moral nature we touch a subject which recalls all that we have said of his intellect, and affirms it with redoubled emphasis. There are reasons for believing that this endowment differs in kind from anything in the nature of the brute. This, to the ability to understand God, adds the ability to sympathize in His moral attributes, and to enter into moral relations with Him and with humanity. Man stands in contact with God. A further approximation is impossible. He must be the limit as he is the existing culmination of organic life.

These various considerations, with others, seem to teach that the column of organic succession is completed in man.- The lower forms gradually and regularly ascending from base to summit, constitute the shaft of the column; but in man we have a sudden expansion, an ornateness of finish, an incorporation of new ideas which designate him as the capital and completion of the grand column of organic existence.

III. *Man's unlimited geographical range.* When the first animals were introduced upon the earth, they found the ocean encompassing it on every side, and creating a uniformity of physical conditions which enabled them to range through every latitude and longitude. In later ages, as the continents, with their mountain ranges, became differentiated from the terrestrial mass, and diverse climates were called into existence, we find that animals were restricted to successively narrower limits. Not only did the growing differentiation of the different regions of the earth lead toward the restriction of the faunas, but there is something in higher organisms themselves which specializes them in their adaptations, and unfits them for so wide a range, even with external conditions unchanged. Thus, as animal life advanced upward, it became more narrowed in the range of its species. The species in possession of the earth immediately previous to man were more restricted than any of their predecessors. It would certainly be expected from all these analogies, that man, on his appearance, would be limited to the narrowest bounds of all. What is the fact? Man overleaps all barriers. Climates, mountains, oceans, deserts form no impediments to his migration. He, the first of all animals, has literally extended over the whole earth, and fulfilled the command to take possession, to use and to enjoy. What does this signify, if not that man is the completion of the series? Animal existence, first narrowed to the smallest limits, in its specific range, then suddenly expanded to the widest. Man occupies the whole earth; he is not only the finishing stroke, but he excludes a successor.

IV. *Man's erect attitude.* When the fish, the earliest representative of the type which embraces man, was introduced

into the waters of the Devonian seas, the vertebral axis was hung in a horizontal position, and the animal was not endowed with even the power to raise the head by bending the neck. Many of the carboniferous fishes acquired this power, but they remained suspended in the element of lowest vital relations. The Triassic and Jurassic Enaliosaurs, while they continued to inhabit the water, breathed the air, and held the head habitually a little elevated. The Crocodilians, to these endowments added the power to *crawl* upon the ground. The Deinosaurs of the Cretaceous age *walked* upon the land with the body elevated above the ground, but the head remaining nearly horizontal. The birds assumed an oblique position of the spinal axis; and most of the Tertiary mammals, which followed them, could carry their attitudes from the horizontal to the semi-erect. The higher monkeys lived normally in a sub-erect position, but still supporting themselves by the four extremities. Man first and alone assumed a perpendicular attitude and turned his countenance toward heaven, and talked with the Being who formed him.

> " Prona cum spectent animalia cætera terram,
> " Os homini sublime dedit; cœlumque tueri
> " Jussit, et erectos ad sidera tollere vultus."

It is evident no further progress can be made in this direction. The elevation of the spinal axis has reached a mathematical limit; the consummation of organic exaltation is attained.

From these various considerations we feel justified in assuming that the Author of nature regards his work as completed. The universal belief of the Christian world, therefore, that the termination of the existence of the human race will mark the consummation of the history of the present order of things, seems to be founded equally in our mental constitution and in the philosophy of the material creation.

THE
ONWARD MARCH OF THE RACE.

By Prof. ALEXANDER WINCHELL, LL. D.

[From the Michigan University Magazine, Vol. II., No. 2.]

IT is the opinion of some that our first parents were created in a state of advanced civilization, and that barbarism is the result of a degeneracy.* It has not been clearly stated what conception of civilization is entertained in enunciating this position; but it clearly cannot be meant to assert that the earliest peoples were in possession of any of those arts or sciences or other appliances of human comfort which we commonly regard as the characteristics of modern civilization. Neither, probably, will it be claimed that the first and second generations had attained so enlarged and exalted conceptions of Deity and of our relations to His moral government, as characterize the theological systems of civilized communities. If it is meant, simply, that man was created with high intellectual and moral capabilities; with the germs of religious ideas implanted in his mental constitution, and a faith in future existence animating his soul, the claim will hardly be disputed. The first man was undoubtedly endowed with the full complement of moral and intellectual faculties; he possessed the power of articulate speech, and probably began immediately to employ it in a rude way; but the expansion of these powers was the work of time. In the progressive advance of life through the geologic ages, the transition from the inarticulate brutes was abrupt. We have no intermediate zoölogical types. Step after step had been taken in the ascending scale, but only brute natures and brute powers had been realized. In the appointed time a being was summoned into existence in whom,

*See for example a paper read by Mr. Franklin Peale before the American Philosophical Society in June last, (Proc. Amer. Phil. Soc., Vol. x. p. 431). Compare also Dr. Clarke's Commentary on Gen. II: 20.

to the character of an animal should be added the attributes of a god. It was a new work. It introduced a new order of existence into creation. Between this creature and his predecessors there could be no parental relations. Brute instinct could never beget a reasoning soul and a moral consciousness.

But yet this being was a barbarian. He was a purely uninstructed, inexperienced, undeveloped intelligence. He could observe, and think, and construct, and adapt means to ends; and it was impossible that he should remain long upon the earth without summoning his powers into exercise. That this was the primitive condition of our race, every consideration teaches us.

Progress is the law of intelligent existence. The two coördinates of intelligent progress are accumulated knowledge and increased power. From the moment the mind begins to act, it begins to retain its experiences and profit by them. From the same moment its active powers begin to acquire new strength. It is impossible that an intelligent man or an intelligent race should ever retrograde or remain stationary. The stand-point reached by a period of high and somewhat abnormal activity may be receded from during a term of slackened mental activity, and thus a relative regression may result. But the mean movement of the race must, by a law of its existence, be onward.

The illustrations of this law cover the pages of history and crowd upon the recollection of every man. Within the memory of the present generation what advances have been made in the elements of a high civilization? Blot out the Atlantic telegraph, the reaper, the mower, the sewing machine, the knitting machine, the railway locomotive, the steam-ship, and we have a representation of the industrial arts as they existed when our fathers first saw the light. To this catalogue, however, we ought to add a hundred forms of machinery of recent introduction for the purpose of accomplishing results previously unattainable, or of multiplying and cheapening the means of human comfort and enlightened progress. Remove from the annals of science the spectroscope and its revelations of the constitution of distant worlds; the chronograph and other recent improvements in astronomical mechanism; blot out a hundred planets from the solar system—including the one whose stupendous circuit embraces all the others; erase nine-tenths

of the names which represent our knowledge of extinct life upon our planet; reduce the structure of geological science to a naked skeleton; strip zoölogy and botany of the grand doctrine of homologies; obliterate the traces of unity in the organic world, whether present or past; abolish the daily newspaper; forget the art of stenography; reëstablish negro slavery throughout half the world; extinguish the light of civilization in western and southern Africa and in Australia; seal up the portals of the Chinese and Japanese empires, and you have a partial representation of the status of the world in science and other important conditions of human happiness and improvement no further back in history than the dawn of the present century.

Tracing the condition of European society still further backward through successive centuries, we see disappearing from the constituents of our civilization, one science, invention and discovery after another, until European society appears confessedly in its infancy. Among inventions, the cotton gin, the spinning jenny, the stove, the steam engine, the art of printing, the mariner's compass, must be subtracted successively from the system of appliances which signalize modern civilization. Among discoveries, the knowledge of the western world, and of the passage to the East Indies by the Cape of Good Hope disappears, together with fire-arms, window-glass, writing-paper, maize, the American potato, and almost numberless minor elements of modern comfort and culture. When we recede to the days of Cæsar's conquests we perceive that a purely barbaric social condition prevailed throughout those regions of central Europe and the British Islands where the very highest type of modern civilization has sprung up. After the Teutons, the Celts, the Danes and the Anglo-Saxons had attained to a condition of semi-civilization, the Russians were still in a state of ignorance and political confusion; and though the light of civilization has encroached far upon the domain of original barbarism, we find the Northern Finns, the Lapps and the Samoyedes still upon the verge of social night.

So far as the evidence goes, the history of every civilized nation exhibits a similar emergence from a state of barbarism. The civilized Roman who overran barbaric Gaul was descended from a savage Pelasgic ancestor who had squatted on the Palatine Hill. The polished Greek who acted as schoolmaster

to the Roman, could trace his pedigree back through various accessions of Egyptian and Phœnician civilization to a primitive, perhaps autochthonous race of savages. The nations of still more ancient civilization — Egypt, Assyria, Phœnicia — as they rise above the horizon of history, are still shrouded in the myths and obscurities which hang about peoples without philosophy, without science, without systematized industry, without a well-digested civil code. The tendency of society has always been progressive. The lapse of the "dark ages" was not a loss of the constituents of civilization; it was a paralysis of the political arm. No arts or sciences dropped out of existence. It was in fact a period which nourished and conserved the literature and science of the ancients, and gave birth to a vast amount of original thought. The exact locus of the apex of human improvement is not always the same. From central and western Asia, it has been transferred, by turns, to Egypt, Greece, Rome, Northern Europe and America. The aborigines of each quarter of the world have been successively illuminated by the spreading and growing flame; but in whatever age we examine the social condition of man we find it in a general process of amelioration.

But there are documents which carry us back beyond the range of both history and tradition. We have fortunately discovered in recent times, traces of the industry and social condition of man at an epoch when, by all admissions he had but lately made his advent upon our planet. The man who antedates the Egyptians, the Assyrians, the Pelasgians, the Indians, has left a record of himself upon the face of Europe. His period reaches back into geologic time. This primeval man saw the decline of the vast continental glacier which, in the preceding age, had swept over Europe, and transformed its Flora, its Fauna and its climate. He looked upon the forms of gigantic quadrupeds now extinct. He listened to the tread of the Hairy Mammoth as he thundered over the plains of southern Europe. He engaged in conflicts with the two-horned Rhinoceros and the wild Aurochs. He fiercely disputed with gigantic bears, and hyenas and lions for the possession of the caverns— the first abodes of men. He was witness, probably, of grand geographical transformations. He saw the British peninsula cut off from the continent by the excavation of the straits of Dover. He saw the American continent exscinded from the

Asiatic by the rupture of the ancient isthmus which connected them. He was thus the contemporary of geological events which we have been accustomed to regard as belonging to the age anterior to man. This discovery, however, does not necessarily carry back the antiquity of our race to a hitherto unrecognized epoch. It shows that these events are more recent than had been supposed — that we ourselves have almost witnessed some of the grand revolutions of the terrestrial surface, and may be, even now, living in a momentary pause in the succession of geological events which transform the world.

The condition of primeval man, beyond all doubt, was that of a barbarian. It was the *infancy* of the race. The relics which illustrate his social and industrial state are such as characterize everywhere the condition of uncivilized tribes. In the remotest epoch — the Stone Age — the use of metals was entirely unknown. His implements, like those of the American savage, were rudely formed of stone. They were few in number, and adapted only to the simplest and most important demands of bodily comfort. His weapons were arrows tipped with flint; his implements, knives and hatchets of stone, for cutting wood and skinning and dissecting animals employed for food and clothing, and, in the latter part of the Stone Age, awls and needles of bone, often with handles of horn. He manufactured rude pottery, without glazing, and generally insufficiently baked. From some specimens dragged from the Swiss lakes, it appears that the art of manufacturing matting, and even cloth of spun yarn had been acquired before the close of the Stone Age.* The ox, the reindeer, the wild boar and the dog had been domesticated, and the flesh of animals was broiled upon sunken stone hearths which still exist. Wheat and barley were cultivated, and stores of grain were laid by in earthen jars. The art of navigation was early discovered. Boats scooped out of a single log have been found buried in the gravel of the Seine and other rivers. It is interesting to remark the indenity between these and the canoe of the North American Indian, and the *kyak* of the Esquimaux.

In process of time the epoch of the *Kjœk-ken-mœd-dings* and lacustrine habitations arrived. Men gathered together in

*Similar matting has been discovered in the salt deposites of Petite Anse on the coast of Louisiana, and it may possess equal antiquity; but of this we have no satisfactory evidence.

villages upon the banks of rivers and bays, and subsisted upon fish and molluscs till the refuse of their meals formed accumulations eight or nine feet high and hundreds of feet in length. For purposes of defense they also constructed habitations upon wooden piles driven in the bottoms of lakes; and, probably, in a still later age — but yet before the advent of the Bronze Age — they constructed rude towers of huge unhewn blocks of stone, many of which stand to the present day, though vastly older than the pyramids. These megalithic structures are known as dolmens and cromlechs, and occur in England, Southern Europe, Russia and reach even into farther India. They were probably the work of the latest men of the Stone Age; and have been referred to the prehistoric Pelasgians, who are supposed to have ranged from India to the Latin peninsula.

In the progress of social development, the uses of tin and copper were discovered, and articles of bronze began to appear. Evidences of the rise of commercial relations make their appearance, and we verge upon the time when the condition of man in Europe approximated to that which prevailed in the middle Pelasgic age, before the introduction of civilization into Greece, and before the dawn of authentic history.

In all that we thus learn of the condition of primeval man there is nothing to show that he enjoyed, or had ever enjoyed, the advantages of a civilized state. We observe, however, that he was always struggling upward. From living in caves he became a dweller in habitations of his own construction. From an isolated condition he gathered himself into communities. From implements of rough stone he advanced to implements of polished stone and of horn and bone, often highly ornamented, and finally, of bronze. From a clothing of skins of beasts he passed to matting and woven cloth. From subsistence upon wild plants and animals he learned to cultivate the cereal grains, and to domesticate beasts useful for food or burden. From this stand-point he has continued to advance through historic time to the present.

It is important to remark that this psychical improvement has not been a zoölogical development. The systematic position of man as a material organism is no higher to-day than in the epoch of the Cave-Bear. Skulls exhumed from gravel-beds which date back to the Stone Age show no marks of inferiority.

Other osteological relics indicate that the human stature has not varied The Cave-Bear folk belonged to the 'same species as the crowned heads of Europe.

Neither has there been any accession to the mental and moral faculties. It is a dream of some that primeval man was mute — that he was destitute of the moral nature of Adam's race — that he was merely an anthropoid being destined to form a transition from the apes to Adamic man. There is little ground for such a hypothesis. Primeval man was not only an organism identical with modern man, but he possessed the same spiritual faculties. He developed constructive skill in the fashioning of his weapons, implements, clothing, habitations and canoes — an allegation which can be made of no other animal. He learned by experience; he was educable; unlike the dog or monkey he was educable without limits. He possessed taste, which can scarcely be predicated of any lower animal. His earthen ware received graceful shapes from his hands, and was often ornamented by rude etchings; his knife and awl handles were sometimes handsomely carved and even wrought into graceful imitative forms; the primeval woman wore bracelets and anklets and beads; and the primeval boy blew his whistle made of the perforated phalangeal bones of the deer or goat. He was even an artist; he made representations on ivory or slate, of the fishes for which he angled, the deer and the bear for which he ranged the forest, and even of the shaggy mammoth whose ponderous form struck terror to the heart of the child, and furnished ivory for the uses of the man. He was a religious being. The traces of his ceremonials attest his service of the unseen God; the attitudes of his burial, and the accompaniments of his corpse attest a faith in the future life.

The development of the race has consisted merely in an education of the mental and moral faculties. Experience has been gained and power developed. Rob the race of all that has been acquired by this long tuition and we should inevitably return to the Age of Stone.

These considerations suggest an inquiry as to the future of the race. The gradual and continuous development of the arts and sciences from the advent of man to the present time affords no ground for supposing the acme of civilization to have been reached. Human progress has indeed gone for-

ward in an accelerated ratio; and this is most strikingly apparent during the half century immediately preceding the present day. It would be illogical to assume that this progress is now to be arrested. The human mind is destined to soar to loftier heights, and human ingenuity to attain to still more marvelous achievements. We are prompted to inquire what unexplored fields our further advance shall invade, but we can only offer conjecture in reply. Would the systematic navigation of the air be more marvelous or more unexpected than the phenomena of the steam-ship, the locomotive or the Atlantic telegraph? What new force in Nature is to be brought to light? What new or broader generalization of physical or spiritual phenomena is to be announced? Shall not the adamatine barrier which walls us out from the realities of the spiritual world be broken down or pierced? We seem now to be on the eve of some grand revelation that shall let in a flood of light from the realm of spiritual existence. In a hundred forms we hear the prophecy uttered; and an irrpressible faith urges us ever onward to break down the unpassed barrier, to tear aside the veil, and open an intercourse with the unseen realities around us. Shall the next step in the march of discovery disclose to us some new mode of existence—some new kind of substance in addition to mind and spirit? Is it absurd to suppose such a substance forms the "spiritual body"—that possessing none of the properties of matter it is circumscribed by none of the limitations of matter—that it is hence invisible and intangible to our gross senses, but may yet be brought within the sphere of a more exalted cognition? Is it idle to hope to attain thus the means of discerning spiritual presence? Shall man always long in vain for the privilege of a glance into the spiritual world, and the happiness of conscious intercourse with the departed? Such queries may be lightly dismissed, but even philosophy lingers fondly around the foreshadowings of such glorious possibilities. Be the veil which hides the future as thick as it will, we have an abiding faith in the continued progress and exaltation of our race.

Dr. Chase's Steam Printing House.

On the Prairies of the Mississippi Valley.

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ON THE ORIGIN OF THE

PRAIRIES

OF THE VALLEY OF THE MISSISSIPPI.

BY

PROFESSOR ALEXANDER WINCHELL.[1]

THE diversity of opinions in existence regarding the cause or causes of the absence of trees from the prairies of the valley of the Mississippi is, of itself, sufficient proof that no satisfactory theory of this phenomenon has as yet been advanced. In the mind of the writer, a conviction has for some time been growing up, that we may discover the origin of the prairies in the last great geological revolution of the globe. The boldness of some of the suggestions about to be offered, ought not to prevent the presentation of them to the judgment of the scientific world.

In discussing the origin of the prairies, it is to be borne in mind that there are two facts to be accounted for—1st. The physical peculiarities of the soil and subsoil of the prairies—2d. The absence of trees from these areas, in cases where no obvious

[1] The original views presented in the following paper were first shadowed forth in an article in the *Ladies' Repository* for May, 1863. The theory was more fully elaborated in a paper read before the Illinois Natural History Society, at Springfield, in June, 1863. As this paper has not as yet been published, I embrace the opportunity of presenting a recast of my views in the present form.

cause exists. The first fact is brought into consideration under the first of the following propositions; the other is discussed under the propositions which follow the first.

1. *The soil of the Prairies is a Lacustrine Formation.*

Some of the older writers on the prairies, confining their attention to the so-called "wet prairies," so common in Ohio and Michigan—now usually termed "marshes," "swales" and "bogs"—found little difficulty in discovering the true origin of this class of prairies, and in proving that the humidity and sourness of the soil were the real causes of the absence of ordinary upland trees from their surface. Other writers, whose observations were made upon the dry and rolling prairies of Illinois, saw no immediate evidence of the aqueous origin of the soil, and knew no cause but the annual burning of the grass, for the remarkable absence of arboreal vegetation. It is this class of prairies to which the present discussion applies. They are conceived to have their origin in more general causes than the marshes and swales before mentioned. The latter have not had a simultaneous origin, and the causes which have brought them into existence have been local and limited in their influence. Being produced by the filling of ancient lakes, one has become a prairie at one epoch, another at another; and the work of filling lakes and forming wet prairies of this class is still in progress. For these reasons, a distinction should be carefully made between the wide, rolling prairies of Illinois and contiguous states, and the local swales of that or other states.

The lacustrine origin of the prairie soil is shown, *first*, by its physical characters. Not only has it the fineness, color and vegetable constitution which characterizes such soil, but we actually discover in it abundant remains of lacustrine shells, disseminated hundreds of miles from the present limits of the lakes. If, among older formations, we are permitted to infer the origin of the sediments from the nature of the included organisms, the evidence from testaceous remains is not less conclusive as to the nature of the prairie sediments.

The lacustrine origin of the soil is shown, *secondly*, by the necessary effect of geological changes of level which are generally admitted to have taken place. From the head of lake Michigan, all the way around the lakes to Niagara river, exist the well known evidences of a former higher level of the waters.[a] Even the increased elevation depending on the position of the falls of Niagara at Queenston—that is to say, the level of lake Erie at the time when the falls began to excavate their great

[a] Hall, *Geol. Rep. 4th Dist. New York*, pp. 348, 383; Lyell, *Travels in N. A.*, *1st Visit*, i, 29, and ii, 85; Desor, *Foster and Whitney's Rep. L. Sup.*, i, 204, 212, ii, 248, 253; Hubbard, *Mich. Geol. Rep.*, 1840, p. 102; Whittlesey, this Journal, [2], x, 31; Logan, *Geology of Canada*, p. 910, &c.

gorge—setting back through the chain of the lakes, would cause a rise in lake Michigan, above its present level, of 25 feet. This small elevation of lake Michigan would probably open an outlet toward the Illinois river. But it is highly probable that the escarpment at Queenston, by extending further north, attained, in consequence, a somewhat higher elevation, at the epoch under consideration. It could hardly be presumed, however, that this was the barrier which dammed the waters of the lakes to the much higher level, of which we have equally the indisputable records. We need but refer to the well known proofs of aqueous erosion along the shores of the lakes, extending from their present levels to the altitude of 200 and 300 feet. Mark them in the escarpments of the south shore of lake Erie; in the lake ridges of Ohio and Michigan;[3] in the caverns and arches and purgatories of Mackinac island[4]—especially in the side of "Sugar Loaf," whose base is now inland and elevated 150 feet above the surface of the water. Whatever may have been the barrier which dammed the waters to these heights, the evidences of their former presence are incontestable. But the moment we grant this ancient level to the waters, they inevitably escape from us toward the south, through the valleys of the Illinois and Mississippi rivers.[5] Turning our attention in this direction we find corroboration of the suggestion. The broad and deep, bluff-lined valley of the Illinois was never excavated by the present inconsiderable river. The deserted river valley discoverable at intervals further north, indicates the former southward flow of a large volume of water. At Lamont, this valley is distinct, with its bounding bluffs and its "pot holes" worn in the solid rock of the ancient river bed. But with the waters of lake Michigan standing one or two hundred feet above their present level, how much of the region south and west of Chicago must have been submerged? The ancient lake must have reached its arms into Iowa, northern Indiana and southwestern Michigan. These, the writer is convinced, were the relative levels of the land and water

[3] We are aware that Col. Whittlesey has attributed the higher ridges to a submarine origin, and that Sir Charles Lyell has advanced the same opinion in reference to the ridges of lake Ontario. In regard to the latter, it will be remembered that lake Ontario is 330 feet lower than lake Erie, and may easily be surrounded by ridges of marine origin, whose level is entirely below the ridges of lake Erie. Further, in reference to the latter, it will be remembered that they have often been found to enclose lacustrine shells. To say the least, even if we do not insist upon the lacustrine origin of the higher ridges, the lower ones, which blend with the terraces of late formation, establish a former altitude of the lakes which is quite sufficient for our present purpose.

[4] Foster and Whitney, *Rep. L. Sup.*, ii, pp. 164-6; Winchell, *Mich. Geol. Rep.*, p. 128.

[5] If the earlier portion of the gorge of the Niagara was undergoing excavation while a large portion of the waters of the lakes was being drained through the valley of the Illinois river, the force and rate of erosion must have been materially diminished below the present standard by the diminution of the volume of water.

for a considerable period immediately following the last great submergence of the continent. This conviction was first reached in the study of the prairies of Alabama, in the years 1851–2 and 3. Shells of *Unio*, *Melania*, &c., are here incorporated with the soil, as in Illinois, but in much greater abundance; and the ancient water-line can be distinctly traced around the bases of the knolls of white limestone, which rise like chalk islands from the bosom of a dark and heaving sea. The aqueous origin of the Alabama prairies was announced by R. W. Withers,[6] and W. W. McGuire,[7] but they both adopted the evidence of *marine* fossils, so abundant in the soil, as proof of the former presence of the sea; and were not at all aware that the submergence of which they saw the proofs had nothing to do with the formation of the prairie soil.[8]

The aqueous origin of the soil of the northwestern prairies was intimated by George Jones in 1836,[9] who compares the prairies and barrens of Illinois to the marshes, dykes and sand flats of Holland. Lesquereux, in 1856,[10] ascribed the general formation of prairies to water, and in 1861[11] reaffirmed his position in reference to the prairies of the Mississippi valley. Prof. J. D. Whitney has distinctly asserted a lacustrine origin for the prairies of the northwest,[12] and Dr. J. S. Newberry[13] has recognized the evidences of a former efflux of the lake waters over the Kankakee ridge in northern Illinois. The indications, indeed, seem to be sufficiently patent to induce the general assent of living geologists to the doctrine of the lacustrine origin of the soil of the prairies.

2. *Lacustrine sediments inclose but few living germs.*

Of the seeds which find their way to a body of fresh water, one portion—embracing the seeds of the grasses and sedges—will float upon the surface, and eventually lodge upon the lee shore. Another portion—embracing the fruits of most arboreal vegetation—will sink to the bottom, and undergo a speedy decomposition. Whenever a lake or a pond has been drained, the bottom remains a naked waste till the germs of vegetation have been gradually introduced *ab extra*. The gradual encroachment of vegetation upon the ancient domain of a lake during the period of its *gradual* drainage or gradual filling up, depends, of course, upon a supply of germs from the main land.

[6] This Journal, xxiv, 187. [7] Ib., xxvi, 93.

[8] So far as the writer is aware, he was the first to assert the lacustrine origin of the Alabama prairies and to maintain it—even in opposition to views then held by Prof. Tuomey.

[9] This Journal, xxxiii, p. 225.

[10] *Bullet. Soc. Nat. Sci. Neuchatel.* [11] See 2d *Geol. Rep. Ark.*

[12] Hall's *Geol. of Iowa*, i, p. 25.

[13] *Proc. Bost. Soc. Nat. Hist.*, vol. ix, May, 1862.

3. *Diluvial deposits, on the contrary, are found everywhere replete with living germs.*

Many of the facts upon which this proposition rests, are matters of common observation, but the broad conclusion does not seem to have impressed itself upon our attention. Nothing is a more common observation than to see plants making their appearance in situations where the same species was previously unknown, or for a long time unknown and under circumstances such that the supposition of a recent distribution of seeds is quite precluded. The following are some of the circumstances under which the sudden appearance of unwonted species occurs.

1st. When a change is produced in the physical condition of the soil. Left to nature, certain perennial grasses secure almost exclusive foothold in our fields, and form a sod in which the ordinary annuals are unable to flourish. Break up the sod, after any number of years, and subdue the perennial grasses, and we shall have a crop of annuals the first season—Veronicas, Chenopodiums, Euphorbias, Portulacas, Ambrosias, Crab-grasses, Fox-tails, Panicums, &c., &c. Cease cultivation, and the Poas and Glycerias will immediately resume possession. Similarly, the pertinacity with which the common Knot-grass (*Polygonum aviculare*) seizes and maintains its position only along the hardest beaten foot-paths is notorious; while the greater Plantain (*Plantago major*) renders itself no less conspicuous growing alongside. Earth thrown out of cellars and wells is generally known to send up a ready crop of weeds, and not unfrequently of species previously unknown in that spot. In all these cases, after allowing for all known possibilities of the distribution of seeds by winds, birds and waters, it still seems probable that germs must have previously existed in the soil.

2d. When a change is produced in the chemical nature of the soil. Illustrations are familiar to every agriculturist. How soon does a dressing of undecomposed muck or peat develop a crop of acid-loving sorrel—and how readily it is again repressed by a dressing of some alkaline manure. Let the waters of a brine well saturate a meadow, and how long before we witness the appearance of *Scirpus maritima*, *Triglochin maritimum* or some other salt-loving plant, whose germs, unless spontaneously developed, must have lain dormant in the soil at a greater or less depth.

3d. The disappearance of dominant species. It is well known that the clearing of a piece of forest and the burning of the brush is almost always followed by the appearance of certain unwonted plants known as "fire-weeds." In many cases it would seem highly improbable that the seeds of such plants have just been transported to such situations, at the moment when the disappearing forest admits the introduction of the conditions essential

to their growth. It can hardly be doubted that the germs existed in the soil, ready to germinate whenever free sunlight, warmth and atmospheric air should be permitted to rouse their latent vital energy. Of the same nature is the recurrence of particular forest growths upon the same soil. Not unfrequently the second growth is of a very different nature from the first. In the "old fields" of Virginia and other southern states, the soil, cleared originally of deciduous trees, and then abandoned, after years of continuous cropping, sends up a growth of pines instead of deciduous trees. Many similar examples will suggest themselves to the mind of the reader.

4. *The living germs of the diluvial deposits were buried during the glacial epoch.*

Whence come the germs of that vegetation which is everywhere springing up in situations to which recent seeds could not have been distributed? This question has agitated the mind of many an inquirer who would have shrunk from the proposition which we here venture to enunciate. Let us examine the facts.

(1.) The vegetation which characterized the close of the Tertiary epoch was probably nearly identical with that existing at the present day under the same climatic conditions. Even in the older Tertiary Lignites, we have, according to the investigation of Lesquereux and Newberry, the remains of plants belonging to the following American genera, viz: *Quercus*, *Carya*, *Populus*, *Acer*, *Morus*, *Carpinus*, *Negundo*, *Laurus*, *Persea*, *Cornus*, *Rhus*, *Olea*, *Rhamnus*, *Magnolia*, *Smilax*, *Thuja*, *Sequoia*, *Taxodium* and *Sabal*—identifications made from scanty and defective material, and we may fairly presume that further investigations will greatly increase the number. Yet these plants, probably older than the Claiborne sands, show, according to Lesquereux, "the greatest affinity with species of our own time." From other beds of the middle or earlier Tertiary, we have still other existing genera, such as *Diospyros*, *Fagus*, *Nyssa*, *Aristolochia*, &c. The facts in our possession relative to the vegetation of the middle and later Tertiary epochs, show a most decided approximation to the existing Flora. From a pleiocene deposit near Somerville, Tennessee, Lesquereux identified the following recent species, viz: *Laurus Carolinensis*, *Prunus Caroliniana*, *Quercus myrtifolia*, *Fagus ferruginea*.[14] From the chalky banks of the Mississippi river, near Columbus, Kentucky, a collection was made of which all the species are recent, viz: *Quercus virens*, *Castanea nana?*, *Ulmus alata?*, *Planera Gmelini*, *Prinos integrifolia*, *Ceanothus Americanus?*, *Carya olivæformis*, *Gleditschia triacanthos*, *Acorus calamus*.[15] It is true that Dr. D. D. Owen has assigned the deposit containing these remains to the Quaternary

[14] This Journal, [2], xxvii, 363. [15] This Journal, [2], xxvii, 364.

period;[16] but as their position is 120 feet below the ferruginous sands containing *Megalonyx Jeffersoni*, and as the nature of these species is incompatible with such a climate as we universally associate with the glacial epoch, it is quite likely this assemblage of vegetable remains represents the general nature of the arboreal flora in existence near the close of the Tertiary period.

Although our positive knowledge of the vegetation of the period immediately preceding the advent of the reign of ice is confessedly meagre, it is certain that all the facts in our possession point to close specific correspondence with the modern vegetation of the same regions—modified certainly by the fact that, even in the latest Tertiary, the climate was considerably warmer than in the same latitudes at the present day.

(2.) The general effect of the events which ushered in and marked the progress of the reign of ice was, to destroy the vegetation flourishing over all the northern portion of the continent and mingle its forms with the cubic miles of *debris* detached from the underlying rocks. We find the trunks and limbs of trees buried 50 and 100 feet deep in this diluvial rubbish. It is impossible that myriads of vegetable germs should not also have been stored away. The drift deposits became the vast granery in which nature preserved her store of seeds through the long rigors of a geological winter.

(3.) But what evidences have we that the seeds of plants are capable of retaining their vitality through a geological period?

(a.) The ordinary process of destruction of vegetable tissues is merely an oxydation of the carbon and hydrogen entering into their constitution. It is seriously doubted whether the requisite conditions for such oxydation exist at considerable depths in the soil. It is stated that the piles sustaining the London bridge have been driven 500 years, and are still comparatively sound. Old Savoy Place, in the city of London, is sustained on piles driven 650 years ago, and they are yet perfectly sound. One of the piles taken up from the bridge built by the emperor Trajan across the Danube, was found petrified to the depth of three-quarters of an inch, while the remainder of the substance was unchanged after an interval of 1,600 years. The buried tree trunks already alluded to must have lain since the time of the last great geological revolution. Nor are these rare cases, for the encroachments of the waves upon the shores of the great lakes reveal whole forests of the buried trunks of the White Cedar, (*Thuja occidentalis*), bearing scarcely a trace of the work of destructive agencies upon them. Indeed it is known that well preserved woody tissue has been frequently exhumed from deposits of Tertiary, and even of greater age. The writer has pieces of drift-wood from the Cretaceous sands of Alabama, in

[16] *Kentucky Rep.*, vol. i, p. 22.

which the ligneous tissue is so fully preserved as to be capable of ignition, like recent wood. Even from the coal measures of Michigan the writer has made preparations of the delicate tissue of Jungermannia-like fronds; and from the coal mines of Lasalle in Illinois, he has specimens of exogenous wood of a brown color and not yet carbonized, though partially pyritized. All these examples tend to show the extreme slowness of the process of decay in ordinary vegetable tissues when excluded from the usual conditions of decay by burial in the earth.

(b.) The oily tissues of which seeds are composed are still more capable of resisting the tendency to dissolution; and ought certainly to remain unchanged, under circumstances which permit such perfect preservation of ordinary ligneous fibre. The evidences are very conclusive, that the seeds of ordinary vegetation may lie dormant in the surface soil for half a dozen or a dozen years. The seeds of *Erechthites* and other "fire-weeds" must have reposed in a latent state during the existence of the forest, whose disappearance is the signal for the resumption of their vital activity. The same is true of the seeds of the "old field pines," which have probably lain for an age or more, awaiting the maturity and destruction of the deciduous forest which usurped the soil. How *many* ages may they have lain there? How many more might they have lain and still been found ready for the first opportunity to seize a foothold?

There are some facts in our possession still more specific. It is well known that Dr. Lindley raised three raspberry plants from seeds discovered in the stomach of a man whose skeleton was found thirty feet below the surface of the earth, at the bottom of a barrow, or burial mound, which was opened near Dorchester, England. With the body had been buried some coins of the emperor Hadrian, from which we are justified in assuming that these seeds had retained their vitality for the space of 1,600 or 1,700 years. If they remained undamaged that length of time, their condition was practically fixed; and who shall say that 10,000 years would have produced a greater effect? Again, Lord Lindsay states that in the course of his wanderings amid the pyramids of Egypt, he stumbled on a mummy, proved by its hieroglyphics to be at least 2,000 years of age. On examining the mummy, after it was unwrapped, he found in one of its closed hands, a bulb which, when planted in a suitable situation, grew and bloomed in a beautiful dahlia. The credibility of this story may be questioned, as the real dahlia is a tuberous-rooted, Mexican genus, not known to botanists till the year 1789. That a bulb of some sort germinated under the circumstances alledged is not wholly incredible. It is further asserted, and generally believed, that wheat is now growing in England, which was derived from grains folded in the wrappings

of Egyptian mummies, where they must have lain for two or three thousand years. Prof. Gray does not fully credit the account, but Dr. Carpenter, the eminent physiologist, gives it his full endorsement. Dr. Carpenter even goes so far as to give utterance to the following observations, which happen to be extremely pertinent to our present argument.

"These facts make it evident," he says, "that there is really no limit to the duration of this condition, [latent vitality], and that when a seed has been preserved for ten years, it may be for a hundred, a thousand or ten thousand, provided that no change of circumstances either exposes it to decay or calls its vital properties into activity. Hence, where seeds have been buried deep in the earth, not by human agency, but by some geological change, it is impossible to say how long anteriorly to the creation of man they may have been produced and buried, as in the following curious instance: Some well-diggers in a town on the Penobscot river, in the state of Maine, about 40 miles from the sea, came, at the depth of about 20 feet, upon a stratum of sand. This strongly excited their curiosity and interest, from the circumstance that no similar sand was to be found anywhere in the neighborhood, and that none like it was nearer than the sea-beach. As it was drawn up from the well it was placed in a pile by itself, an unwillingness having been felt to mix it with the stones and gravel which were also drawn up. But when the work was about to be finished, and the pile of stones and gravel to be removed, it was necessary also to remove the sand heap. This, therefore, was scattered about the spot on which it had been formed, and was for some time scarcely remembered. In a year or two, however, it was perceived that a number of small trees had sprung from the ground over which the heap of sand had been strewn. These trees became, in their turn, objects of strong interest, and care was taken that no injury should come to them. At length it was ascertained that they were Beach-plum trees, and they actually bore the Beach-plum, which had never before been seen except immediately upon the sea-shore. The trees had therefore sprung from seeds which were in the stratum of sea-sand that had been pierced by the well-diggers."[17] It cannot be doubted, as Carpenter concludes, that the seeds of the Beech-plum had lain buried since the remote period when that part of the state was the shore of the slowly receding sea.

Such a fact, so striking and so circumstantially recorded, is only of the same nature as others less critically noted, which daily pass before our eyes, in the upspringing of vegetable forms from the diluvial materials thrown out of wells, cellars and other excavations.

[17] Carpenter's *Elements of Physiology*, Am. ed., p. 41.

It must be confessed that the crucial observation is yet to be made. If vegetable germs exist in the drift, they can be discovered beforehand. The writer is not aware that any thorough search has ever been made for them; but until they have been actually detected, it is probable that even the convincing facts cited above will fail to secure universal assent to our proposition involving the prolonged vitality of the seeds of preglacial vegetation. While, however, the case is far from demonstrated, it may fairly be submitted that the explanation of certain facts, afforded by our theory, is less presumptuous and improbable than the supposition of spontaneous generation, the fortuitous distribution of seeds by any modern agency, or any other explanation which can be reasonably offered.[18]

5. *In proportion as the diluvial surface became exposed, the Flora of the preglacial epoch was reproduced.*

As the continent slowly rose from its last sea-burial, every portion of its surface, inch by inch, passed under the action of the ocean's surges. Even if the vegetable germs inclosed in the more superficial portions of the drift deposit had yielded to the destructive agencies of a geological period, the action of the sea would have uncovered and brought to light some of the more deeply seated and better protected seeds. If, then, our reasonings are correct, returning spring time vivified into activity the myriads of germs stored away by Nature from before the reign of ice; and the continent was again clothed with those forms of verdure which had adorned it at the close of the Tertiary period. But at this moment in the world's history, the retreating waters paused to brood over the wide region destined to become the garden of the west; perpetual dilution converted them into a vast inland sea of fresh water, upon whose bottom gathered the lifeless sediments that were to be the soil of the prairies. Then, when, in the progress of events, either through the removal of barriers, or the further upheaval of the land, the fresh waters were poured from the wide prairie region, there remained a naked and lifeless expanse of vegetable slime. From the bosom of the slime no plant could start, for the germ was not there. From beneath the load of slime, in the diluvial deposits below, no plant could raise its head, for it was sealed hermetically from air and light and warmth. A shining coat of

[18] With reference to the effect of sea water on the vitality of seeds during the epoch of submergence of the continent, we have not overlooked Darwin's experiments recorded in the London *Gardeners' Chronicle* for May 26th, 1855. While the experiments show a wonderful power of resisting the destructive influence of sea water, it is still apparent that the conditions of the experiments were such as to throw no light on the fate of seeds buried deeply in a submarine sand bed. It will be remembered further, that the filtration of sea water through a mass of sand, deprives it of its saltness, so that this agency in the destruction of vegetable germs embraced in a submarine soil becomes to a great extent eliminated. Compare Cabot, *Proceedings Bos. Soc. Nat. Hist.*, vol. iii, pp. 92, 103.

verdure clothed everywhere the more ancient surface of the drift; and here and there in the abandoned lake bottom, rose a knoll crowned with its emerald crest—an island perhaps in the former lake. Thus the prairies were at first a naked and herbless waste.

6. *The vegetation which finally appeared on the drained lacustrine areas was extra-limital, and was more likely to be herbaceous than arboreal.*

The natural agencies in the introduction of vegetation from beyond the limits of the prairie region would be winds, running water and animals—especially granivorous birds. In a region so nearly level, the agency of running water would bè but feebly exerted. Winds would exert a more important influence in the dispersion of the lighter, and especially the feathered seeds; but granivorous birds, it is believed, would exert a still more important influence. Yet it will be noticed that none of these agencies, and especially the two more important ones, would effect the distribution of any except the smaller and lighter seeds. Numerous quadrupeds, it is true, engage in the transportation of nuts and acorns, but no suitable storage place for such fruits would be found upon the prairies, not to mention the fact that they are transported and stored for consumption rather than for seed. It can hardly be doubted that the humble forms of vegetation producing the lighter seeds would be the first to secure possession of the soil. Sedges and marsh-loving grasses, especially, would eagerly occupy the ground, until the chances of germination of any of the larger fruits, would become exceedingly diminished. Thus the prairie became covered with herbaceous vegetation exclusively, while all around the margins was arrayed a shining fringe of forest trees, and every island knoll stood crowned with its cluster of oaks. Around the borders of the prairie were the ancient sand dunes, blown up while yet the prairie was a lake bottom. A peculiar vegetation would suit itself to so purely arenaceous a soil; and an occasional tree would be able to plant itself along the belt thus destined to become the "barrens."

Thus the prairies were treeless because the grasses first gained foothold and then maintained it. The Indian, perhaps, made his appearance at this time, and formed an alliance with the grasses in their contest against the trees; and thus decided the question in favor of the grasses.

This is our theory of the origin of the prairies, and the absence of trees from their surface. Fatal objections may rest against it, but it is certain that all other theories are untenable.

1. The old and popular belief that the treelessness of the prairies was caused by the annual burning of the grasses by the Indians,[20] is now generally admitted to be inadequate.

2. The supposition that trees have been choked out by the tangled roots of cane, which in turn has disappeared under the influence of a burning sun,[21] has no applicability in a region visited annually by frosts too severe for cane to survive.

3. The supposition that the absence of trees is due to too great dryness of the soil during the summer, is disproved by the fact that trees flourish naturally in drier soils in the same vicinity, while, on being introduced, they flourish equally well in the prairie. The treeless and almost herbless deserts of the far west may have originated in extreme aridity of the atmosphere[22] —as others have from the highly saline character of the soil— but all our discussions have had reference to the prairies of the Mississippi valley.

4. A theory often urged is the considerable humidity of the soil of certain prairies,[23] and especially the wetness of the subsoil in contrast with the dryness of the soil during summer.[24] It is singular that such an opinion could be entertained when it is so well known that there is no situation so wet but certain trees will flourish on it—the willow, the cottonwood, the beach, the ash, the alder, the cypress, the tupelo, the water-oak, the tamarack, the American arbor-vitæ or some other tree—some of them standing joyously half the year, if need be, in stagnant water. It is well known that swales are generally devoid of trees; but the reason for this is to be found in the fact that since a soil assumed the place of the ancient lake, the germs of trees have never been introduced; while the introduction of such germs is delayed by the circumstance that neighboring forests are generally such as are adapted to drier situations. Has it been found that a green willow or poplar twig will not root and thrive in a wet prairie? But further than this, large portions of the treeless prairies are *not wet.* Is there a different cause for treelessness here?

5. Prof. J. D. Whitney[25] has advanced the opinion that the extreme fineness of the prairie soil is the cause of the absence of trees; and the author of the article on "Plains," in the New American Cyclopedia, seems to have adopted this view. Against this theory we see several weighty objections. Many alluvial soils, as pulverulent as that of the prairies, are densely

[20] This Journal, vol. i, p. 331. [21] This Journal, vol. xxiii, p. 40.

[22] Does Prof. Dana allude to the prairies of the Mississippi valley when he says, (*Manual of Geol.*, p. 46), "and where the moisture is not sufficient for forests, she [America] has her great prairies and pampas?" See also Cooper, *Smithson. Rep.*, 1858, p. 276; Newberry, *Ohio Agric. Rep.*, 1859; Lambert, *Pacific R. R. Rep.*, vol. i, p. 166.

[23] Atwater, this *Journal*, i, 116; Bourne, *Ib.*, ii, 30; Lesquereux, *2d Ark. Geol. Rep.; Western Monthly Magazine*, Feb., 1836

[24] Engelmann, this *Journal*, [2], xxxvi, 384. [25] *Iowa Geol. Rep.*, vol. i, p. 24.

wooded, and that in the same latitudes and under the same meteorological conditions. Again, partial or complete destitution of trees is observed on the coarser, sandy borders of the prairies, and on all recent sand dunes, even where no lack of vegetable sustenance exists. But the fatal objection to this theory, and all theories which look to the physical or chemical condition of the soil, or even to climatic peculiarities, for an explanation of the treeless character of the prairies, is discovered in the fact that *trees will grow* on them when once introduced—not water-loving trees exclusively, but evergreens, deciduous forest trees, and fruit trees—such as flourish in all the arable and habitable portions of our country. Everybody now knows that trees flourish well on the prairies; and the prairie farmers are actively engaged in their introduction.[26] It seems to us that this fact alone militates fatally against the views advanced by Whitney as well as those of Engelmann, Bourne, Atwater and others, who have attributed the distinctive character of the northwestern prairies to an excessive humidity of the soil.

University of Michigan, Aug. 30, 1864.

[26] Compare Wells, this Journal, i, 331, where the forest is said to be encroaching on the prairies about St. Louis; Engelmann, Ibid. [2], xxxvi, 389; Edwards, *Rep. Dep. of Agric.*, 1862, p. 495.

POSTSCRIPT TO PROF. WINCHELL'S ARTICLE ON THE ORIGIN OF PRAIRIES.

[Page 444 of the November No. of the Journal of Science.]

In my article on Prairies, the belief is expressed that the assumption of the possibility of the almost indefinite suspension of the vitality of seeds, required by my theory, would present the greatest obstacle to its reception. It seems excusable, therefore, to crowd into a postscript, a reference to evidences temporarily overlooked, and especially to testimony and facts collected by Mr. Marsh in his learned work, "*Man and Nature*," page 285, *et seq.* This work has but just fallen into my hands. Mr. Marsh thinks, with Dr. Carpenter, that the vitality of seeds "seems almost imperishable while they remain in the situations in which nature deposits them." He cites numerous instances in which one crop of plants has disappeared on a change of conditions, and another, of different nature, has promptly assumed its place, originating, evidently, from seeds preëxisting for ages in the soil. He says "earth brought up from wells or other excavations soon produces a harvest of plants, often very unlike those of the local flora." He expresses the opinion that earth ejected from considerable depths by a certain earthquake convulsion, to which reference is made and which soon became covered with vegetation "never observed in that region before," must have brought up with it the seeds from which the novel vegetation sprang, under "the influence of the air and sun, from depths where a previous convulsion had buried them ages before." In the same connexion may be quoted a statement by Darwin (*Origin of Species*, Am. ed., p. 69), to the effect that in the midst of a very large and very sterile heath in Staffordshire, some hundreds of acres were planted with the Scotch fir, and, after twenty-five years, not less than twelve species of plants (not counting grasses and sedges) had made their appearance in the plantation of firs, "which could not be found in the heath"—and this, though the fir forest seems to have been visited only by insectivorous birds.

Mr. Marsh quotes from Dwight's *Travels* his account of the appearance of a fine growth of hickory [*Carya glabra* Torr.] on lands in Vermont which had been permitted to lie waste, when no such trees were known in the primitive forest within a distance of fifty miles; also, Dr. Dwight's account of the appearance of a field of white pines, on suspension of cultivation, in the midst of a region where the native growth was *exclusively* of angiospermous trees. "The fact that these white pines covered the field exactly, so as to preserve both its extent and figure," says Dr. Dwight, "and that there were none in the neighborhood, are decisive proofs that cultivation brought up the seeds of a former forest within the limits of vegetation, and gave them an opportunity to germinate."

The existence of a succession of forests of different prevailing species has been satisfactorily established in Denmark by the researches of Steen-

strup on the *Skovmose*, or Forest-bogs, of that country (*Mem. Acad. Sci. Copenhagen*, ix, 1842). These bogs are from twenty to thirty feet in depth, and the remains of forest trees in successive layers, prove that there have been three distinct periods of arborescent vegetation in Denmark—first, a period of the pine (*Pinus sylvestris*)—secondly, a period of the oak (*Quercus robur sessiflora*)—lastly, a period of the beech (*Fagus sylvatica*), not yet arrived at its culmination. The dominant species of each period flourished to the entire exclusion of the other two species, (see *Smithsonian Report*, 1860, p. 305, *et seq.*) Cæsar affirms that the *Fagus* and *Abies* were, in his time, wanting in England, but the beech (*Fagus*) is now plentiful, and Harrison tells us in his "*Historicall Description of the Iland of Britaine*" (*Holingshed's Chronicles*, 1807, i, 359), that "a great store of firre" is found lying "at their whole lengths" in the "fens and marises" of Lancashire and other counties, where not even bushes grew in his time. (See further, Marsh's *Man and Nature*, p. 222.) No doubt such extinct forests have flourished in America, even since the Glacial epoch, and have stocked the accumulating soils with their stores of vitalized fruitage, awaiting some future resurrection; and no doubt the "fens and marises" of Lancashire, under suitable circumstances, would reproduce from their granaries of forest fruit, the arboreal vegetation which had flourished and disappeared before the Roman conquest.

Ann Arbor, Mich, Oct. 15, 1864.

[From the American Journal of Science and Arts, Vol. XL, Nov., 1865.]

SOME INDICATIONS OF A NORTHWARD TRANSPORTATION OF DRIFT MATERIALS IN THE LOWER PENINSULA OF MICHIGAN.

By Professor ALEXANDER WINCHELL.

Throughout the northern part of Lenawee and Hillsdale counties, the southern and eastern parts of Jackson, and the southern and western parts of Washtenaw county, are found numerous tabular, detached masses of limestone, sometimes cropping out on a hill side, like a ledge in place, and sometimes imbedded two or three feet in the sand and gravel at the summit. The position of these masses is generally nearly horizontal, though for the greater part slightly tilted in one direction or another. They sometimes present an extent of six, eight, or twelve feet square; and in occasional instances even more, so as to offer every appearance of an outcropping formation. In some cases many hundred bushels of lime have been burned from them before exhaustion. Underneath them we find the semi-stratified drift materials so characteristic of the general surface of the peninsula. At the bottom of the drift, which in some places is not over ten or twenty feet deep, we find the rocks of the Huron, or more frequently the Marshall group, in place. Many patches, nevertheless, occur as far north as the outcrops of the Carboniferous limestone, and create great confusion in tracing the latter formation unless the fossils are strictly attended to. Smaller fragments of the same limestone are still more abundant throughout the same limits; and, by their disintegration,

have imparted a highly calcareous element to the soil, even along the arenaceous belts. The percolation of meteoric waters, in turn, has given rise, in great abundance, to calcareous springs, and deposits of marl, tufa and travertin.

In the southwestern part of the peninsula, in the counties of Berrien, Van Buren and Ottawa, similar phenomena are again observed. The calcareous element of the soil is even more abundant; and large patches of sand have become firmly cemented, so as to present the consistency and appearance of ledges of sandstone. It really requires an extended series of observations to convince one's self that the region does not furnish considerable outcrops of a sandstone formation—especially as numerous blocks of undoubted Marshall sandstone occur upon the surface.

Some examples of these phenomena may be more definitely cited. On the S.W. ¼ S.E. ¼ sec. 13, Woodstock, Lenawee County, (221),[1] in the side of "Prospect Hill," limestone occurs in tabular masses six by twenty feet, and seven feet thick. An old lime-kiln stands near. Similar limestone occurs on the S.E. ¼ S.W. ¼ sec. 12, Woodstock (223) and S.W. ¼ S.E. ¼ sec. 1. From the latter locality several hundred bushels of lime have been burned. On sec. 3 of the same township, the Marshall sandstone is reached at the depth of 4 to 12 feet from the surface. On sec. 4 the sandstone is known to be over 75 feet thick; so that there can be no mistake in assuming it to be in place. On the N.E. ¼ N.W. ¼ sec. 6, Woodstock (230), is a large tabular mass 10 feet long and known to be over 6 feet broad. The dip is toward the east.

On the N.W. ¼ N.W. ¼, sec. 32, Columbia, Jackson county, (233) is a mass of limestone. Sixty rods north of here the sand-rock is known to be within 20 feet of the surface, and has been penetrated 44 feet. On sec. 30 it has been penetrated 60 feet. On the N.W. ¼ N.W. ¼ sec. 26, Liberty, Jackson county, (235), masses of limestone are so abundant that a kiln has been constructed and several hundred bushels of lime manufactured. At the time of my visit, about 35 cords of wood were piled by the kiln, indicating considerable confidence in the resources of the quarry. Fragments of Marshall sandstone, with its fossils, are abundant, mingled with the fragments of limestone. Similar masses of limestone may be seen again on N.W. ¼ N.E. ¼ sec. 26, Hanover, (239), and on the S.W. ¼ N.E. ¼ same section, (240). Several wagon loads of fragments have been removed from the subsoil over the principal mass at the latter place. On the S.E. ¼ S.E. ¼, same section, a common well reached the Marshall sandstone at the depth of 35 feet, and was excavated 40 feet in the rock. The hills on N.E. ¼ N.E. ¼ sec. 33, same township,

[1] These numbers designate the localities.

(243), are filled with fragments of limestone, while the Marshall sandstone is struck at the depth of 50 feet on sec. 35, and at 30 feet on sec. 27. Farther north, on secs. 10 and 11, Leoni, (92 and 206), similar fragments again occur. Also on sec. 25, Grass Lake, (208). At a place one mile northeast of Franciscoville, (209), 20,000 bushels of lime have been manufactured in ten or twelve years.

In the adjoining parts of Washtenaw county, several kilns proclaim the presence of extensive nests of limestone. Even within the corporate limits of the city of Ann Arbor an extensive deposit has been quarried; and just beyond the limits, on the east, are the ruins of a limekiln which, many years ago, exhausted still another deposit.

Similar masses of limestone occur in Hillsdale county, one half mile southwest of Jonesville, (270); on S.W. ¼ N.W. ¼ sec. 21, Allen, (274); N.E. ¼ N.W. ¼ sec. 21, Adams, (289); S.E. ¼ N.E. ¼ sec. 22, Adams, (291); N.E. ¼ N.E. ¼ sec. 24, Adams, (292); S.W. ¼ N.W. ¼ sec. 19, Woodbridge, (296), and in many other localities.

In the southwestern part of the state, on the S.E. ¼ N.W. ¼ sec. 11, Hartford, Van Buren county, (415), limestone is found within two feet of the surface over the space of three or four square rods. One hundred rods north of here the wells are from 40 to 100 feet deep, without reaching any native rock—though thick beds of cemented sand and gravel are frequently encountered.

On the S.W. ¼ sec. 17, T. 7 N.R. 13 W, Ottawa county, (438) is the last occurrence that will be cited. Several slabs 3 or 4 feet long have been removed, and others remain, over an area of at least a square rod.

It is quite evident that such masses of stratified limestone have not been rolled to the same extent as the quartzose and gneissoid boulders which constitute the most striking feature of the "northern drift" of the same regions. By some agency these tables have been lifted gently from their original sites and carefully deposited where we find them. Paying no regard to their included fossil remains, it might be imagined that they constitute the ruins of the Carboniferous limestone formation, whose place is between these fragments and the centre of the peninsula. This formation gently rises toward the periphery of the peninsula, and at certain distances from its present outcrops would intersect the highest diluvial hills in the places occupied by the fragments which I have described; and which, for this reason, might be imagined as marking the outermost limits of a once continuous formation of Carboniferous limestone. The abundant fossil remains contained in these fragments, however,

not to speak of their lithological characters, convince us that the rock belongs to a much earlier epoch.

In short, no doubt could be entertained by one who has examined the subject, that these fragments appertain to the age of the Corniferous limestone. The rock, in structure, is irregular, often brecciated, with streaks and nests of bituminous and argillaceous matter. At other times it is compact and massive. Not unfrequently it presents the peculiar structure known as "lignilites." All these characters belong to the Corniferous limestone as exposed along the western shore of Lake Erie, and at numerous points throughout the county of Monroe.

Turning to the more reliable evidence of the fossil remains, it may be stated that the following are examples of the more frequent identifications:

At 92, *Heliophyllum Canadense* Billings, *Clisiophyllum Oneidaënse* Bill., *Acervularia Davidsoni* E. & H., *Conocardium trigonale* Hall, *Proetus crassimarginatus* Hall, *Amplexus* and *Favosites.*

At 182, *Lucina proavia* Goldf., *Conocardium trigonale*, *Dentalium* and *Fenestella.*

At 208, *Lucina proavia* and three species of Bryozoa.

At 230, *Strophomena rhomboidalis* Wahl, *Chonetes glabra* Hall, *Spirifera gregaria* Clapp, *Atrypa reticularis* Dal.

At 233, *Chonetes hemispherica* Hall, *Atrypa reticularis, Cyrtodonta* (*Vanuxemia*) *Tompkinsi* Bill, *Pleurotomaria rotunda*, Hall.

At 270, *Chonetes lineata* Hall, *Atrypa reticularis.*

At 289, *Chonetes lineata, C. glabra* Hall, *Atrypa reticularis, Leiorhynchus multicosta* Hall, *Rhynchonella Thalia* Bill., *Lucina proavia*, *Proetus crassimarginatas* Hall, *Platyceras and Proetus* sp.?

At 291, *Cyathophyllum Zenkeri* Bill, *Chonetes lineata, C. glabra, Orthis Vanuxemi* Hall, *Strophomena hemispherica, S. rhomboidalis, Spirifera varicosa* Hall, *S. gregaria, Atrypa reticularis, Charionella scitula* Bill., *Rhynchonella Thalia, Lucina proavia, Conocardium trigonale, Proetus crassimarginatus, Fenestella, Producta* (two species), *Streptorhynchus, Athyris, Platyceras.*

At 292, *Orthis Vanuxemi, O. propinqua* Hall.

At 296, *Chonetes glabra, C. arcuata* Hall, *Stricklandia elongata* Bill.

At 298, *Strophomena hemispherica.*

The following are the more common Corniferous fossils occurring in the Drift at Ann Arbor:

Favosites Gothlandica Goldf., *F. cervicornis* De Blainv., *F. turbinata* Bill., *F. polymorpha* Goldf., *F.* (*Emmonsia*) *hemispherica* Y. & S. sp., *Fistulipora Canadensis* Bill., *Michelinia convexa* D'Orb., *M. favosoidea* Bill., *Alveolites labiosa* Bill., *A. Rœmeri*[2] Bill., *Syringopora perelegans* Bill., *S. Hisingeri* Bill., *S. Maclurei* Bill., *S. nobilis* Bill, *Stromatopora concentrica* Lonsd., *Cyathophyllum Zenkeri* Bill., *Zaphrentis prolifica* Bill., *Clisiophyllum Oneidaënse* Bill.,

Heliophyllum Eriense Bill., *H. exiguum* Bill., *Cystiphyllum Americanum* E. & H., *Blothrophyllum decoricatum* Bill., *Diphyphyllum Archiaci*[2] Bill., *Phillipsastræa Verneuili* E. & H., *P. gigas* Owen, sp., *Acervularia Davidsoni*[2] E. & H., *Tentaculites scalaris* Schlot., *Chonetes glabra* Hall, *C. hemispherica* Hall, *Strophomena hemispherica* H., *S. perplana* Con., *S. inæquiradiata* H., *S. demissa* Con., *Orthis propinqua* H., *O. Eryna* H., *Ambocœlia umbonata* Con., sp., *Spirifera gregaria* Clapp, *S. varicosa* H., *S. acuminata* Con., sp., *Leiorhynchus multicosta*[2] Hall, *Nucleospira concinna*[2] Hall, *Charionella scitula* Hall, sp., *Atrypa reticularis* Dal., *A. impressa* H., *A. aspera?* Hall, *Meristella unisulcata* Con., sp., *M. nasuta* Con., sp., *Leptocœlia concava* H., *Pentamerus aratus* Con., sp., *Stricklandia elongata* Vanux., sp., *Centronella glansfagea* Hall, sp., *Rhynchonella Thalia* Bill., *Lucina proavia* Goldf., *Conocardium trigonale* Hall, sp., *Platyceras Thetis* H., *P. crassum* H., *P. dumosum* Con., *Platyostoma strophius* H., *Murchisona Leda* H., *Proetus crassimarginatus* H., and more than two dozen species which seem to be undescribed.

If no reasonable doubt exists that these detached masses belong to the Corniferous limestone, the next question which presents itself relates to the region whence they have been derived. In view of the facts cited, it is evidently absurd to assume that no transportation has taken place; for these masses of Corniferous limestone are found resting over the Hamilton group, the Marshall group and the Carboniferous limestone—and, I am pretty well convinced, even in some cases, as far north as the Coal measures. There are insuperable objections to assuming that they have been transported with the great mass of drift materials from the northern outcrops of the rocks of this age at Mackinac and the surrounding region. *First*, the transporting agency has not moved masses of other kinds of rocks which attain to anything like the same dimensions. *Secondly*, That agency, if we may judge from the condition of the siliceous, trappean and gneissoid boulders of admitted northern origin, would have ground to powder so fragile and friable a rock as these limestones; or at least would have broken them into small fragments, and deposited them in a worn and rounded condition. *Thirdly*, If the Corniferous limestone could have been transported in such masses from its northern outcrops to southern Michigan, much more would the harder and more massive Niagara limestone of the same regions have been similarly

[2] These species of the Hamilton group are here included, because occurring in the same fragments with admitted Corniferous (and Schoharie grit) species. The Lower Helderberg *Leptocœlia concava* is included for the same reason. In none of the cases just referred to, however, do we experience any difficulty in discovering slight constant peculiarities in the Corniferous species. The richness of the exotic Drift fauna of this locality, in the number and state of preservation of its remains, far exceeds any that has been signalized by the geologists of the Old World.

transported. The same may be said of the Trenton limestone. We find, however, that fragments of these limestones are of rare occurrence; and the fossils of Silurian age scarcely sustain to those of the Corniferous limestone the ratio of one to one hundred, in the drift deposits of the southern portion of the state. Even the Carboniferous limestone, whose outcrop extends through Kent, Eaton, Jackson and Oakland counties, is scarcely represented among the drift materials of the region in question. It is apparent that we must look in another direction for the origin of these lost rocks.

The nearest outcrop of the Corniferous limestone is in northern Indiana and Ohio, and the southeastern corner of Michigan[a]. Every fossil cited above is found in place in some part of that region. The formation dips under the peninsula of Michigan; and, throughout the area occupied by the lost masses in question, it lies from one hundred to twelve hundred feet beneath the surface—the depth of course increasing toward the center of the Carboniferous area. The circumstances suggest the exertion of some powerful agency acting northward with tremendous energy, but with a gentle and equable movement. It would seem as if the summit of the low anticlinal in the Corniferous limestone to the southeast of Michigan had been immersed in a shallow sea or lake, the freezing of which had incorporated the upper layers of the rock in an immense thickness of ice, which, by a rise in the water, had floated off as enormous ice-floes, bearing their cargoes of limestone northward till deeper and milder water loosened their icy hold, or they became stranded on the bosses which mark the belt of the Marshall sandstone. From the position of these masses in the "Modified Drift," as well as from the direction and gentleness of the movement, it would seem impossible that the events should have been contemporaneous with the actions which characterized the great glacial epoch.

Additional facts exist which seem to lead the mind further toward a belief in a northward acting post-glacial agency. The fossils of the Hamilton group, whose outcrop is along a belt lying somewhat farther north than the Corniferous limestone, are scattered through the soil of the region lying still farther north, in a degree of abundance which bears about the same ratio to that of the Corniferous fossils as the attenuated Hamilton rocks bear to the Corniferous. Indeed it may be said that *Spirifera mucronata* is the most abundant single species in our drift; as it was certainly the most abundant species that lived in these parts of the Lower Devonian sea. Other common species of the Hamilton group are *Ambocœlia umbonata* Hall, *Cyrtia Hamilton-*

[a] It probably underlies the drift materials of the southwestern angle of the state and the adjacent parts of Indiana, but no actual outcrops are known to exist.

ensis Hall, *Spirifera Marcyi* Hall, *Spirigera concentrica* Brown, sp., *Platyceras attenuatum* Hall, *Dalmania Boothi* Green, sp., and many others. These species exist in an admirable state of preservation, quite incompatible with the theory of their transportation from the far north; and they occur across a belt of the state reaching at least thirty miles north of the outcrop of the Hamilton rocks.

Again, above the identifiable Hamilton rocks, we find, in this state, a great thickness of argillaceous and bituminous shales, destitute of fossils, but freighted with Kidney iron ore. Nodules of this ore are strewn not only over the region of the outcrop of these "Huron" shales, but throughout Washtenaw and other counties lying over the upper Devonian and lower Carboniferous strata—to say nothing of the occurrence of such nodules within the limits of the Coal measures, where, by some geologists, they might preferably be referred to the indigenous strata.

Still again, the well marked fossiliferous beds of the Marshall sandstone, lying next above the Huron shales, and outcropping along a belt still farther north, is represented by a series of enormous fragments resting over the non-fossiliferous upper portions and the Carboniferous limestone. The lower, or fossiliferous portions of this formation do not outcrop farther north than Moscow, in Hillsdale county, while fragments of it have been transported in great abundance into the southern townships of Jackson county. The most notable example occurs in a deep railroad cut three miles north of Napoleon, where the abundant fossiliferous fragments led me for some time to suppose the actual outcrop must be in the immediate vicinity; although I had found the non-fossiliferous Napoleon sandstone intervening between the locality and the most northern known outcrop of the fossiliferous beds at Moscow. I collected here a large proportion of the common fossils of the Marshall group such as *Rhynchonella Sageriana*, *Chonetes pulchella*, *Myalina Michiganensis*, *Cardiomorpha modiolaris*, *Tellinomya Hubbardi*, *T. Stella*, *Pterinea crenistriata*, *Cardium Napoleonense*, *Solen scalpriformis*, *Bellerophon galericulatus*, *Orthoceras Indianense*, *Goniatites Marshallensis*, and numerous other species. The fossiliferous layers of the Marshall sandstone are decidedly friable—insomuch that it is in little request for building purposes—and it would seem absurd to suppose that these large fragments had been moved two hundred miles from the northern outcrop of the formation, when a transfer of ten or fifteen miles from the southern outcrop would bring them to the position which they occupy. We should expect, also, if derived from the north, that some contrast in the organic facies, due to local, if not to climatic causes, would present itself; but on the contrary, we find the fauna of

the fragments strictly identical with that of the nearest indigenous rocks of the same age.

The facts above cited recall some observations made several years since in Alabama, and which led at that time to impressions similar to those just set forth. My observations were made especially upon the neighborhood of the junction of the "Rotten Limestone" of the Upper Cretaceous, with the argillaceous and arenaceous strata of the Lower Cretaceous. The "Red Loam" of the central belt of the state, which I have evidences to prove to be but the Rotten Limestone altered *in situ*, or with slight transportation, has in many cases along the junction of the upper and lower strata, been moved northward over the clayey and sandy region appertaining to the lower Cretaceous; where, by its admixture with diluvial sand and pebbles, it is proved to be an exotic formation.

I forbear to express any belief in reference to the former existence of a transporting agency acting from the south to the north, over all or any portion of the interior of the continent; but such facts as I have cited cannot fail to call to mind the suggestions made some years since by President W. Hopkins, touching the course the Gulf Stream would necessarily pursue, in case of the subsidence of the North American Continent[4]. The facts are of sufficient importance to merit investigation; and it is to be hoped that other observers will inform us whether they are exceptional phenomena, or correspond, in connection with others, to some ancient, glacial or hydrographical area.

University of Michigan, August 4, 1865.

THE WEDDED WATERS.

BY MRS. A. WILTSE.

FAR from life's busy scenes and bustling crowds,
Where snow-crowned mountains fondly kiss the clouds,
Missouri, daughter of the glorious West,
Sprang into light.

Pure infant streamlet, like a silver thread
Unwinding seaward, as by fancy led,
Thou fall'st from craggy rocks in bright cascades
And crystal rills.

Earth's garnered treasures yield a gleam of ore,
A touch of beauty from her precious store;
From hidden cleft thou comest murmuring forth
O'er sands of gold.

The gathered waters from unnumbered streams,
Brewed 'mid the rocks, distilled in deep ravines,
Unite with babbling brooks from gushing springs,
To swell thy form.

Streamlet no longer, but a river grand—
Broad, rushing, regal, proudest in the land—
Sweep onward; in thy mighty majesty
Thou reign'st a queen.

From distant clime, where pure Itasca glows,
Great Mississippi, fed by northern snows,
With waves murm'ring sweet music, southward sped
To claim his bride.

Ere yet the Indian, in his birch canoe,
With arrowy speed adown the waters flew,
In fond embrace the beauteous rivers met,
Never to part.

Sun, moon and stars joined in the marriage chimes;
All nature's voices woke in heavenly rhymes;
No human presence marred the glorious scene
Of perfect joy.

Lo! in a mighty and harmonious one,
The wedded waters sweep beneath the sun,
Brightening the shores while journeying oceanward
With ceaseless flow.

Whether in ice-locked fetters winter-bound,
Or softly flowing with melodious sound,
Flashing in sunshine, whitening in the storm,
United still.

Symbol most perfect of a marriage true,
By hosts *attempted*, but *attained* by few;
Union sublime—two blended into one—
Forevermore!

THE OLD AGE OF CONTINENTS.

BY ALEXANDER WINCHELL.

"TIME writes no wrinkle on thine azure brow," said Byron, as he laid his hand upon old ocean's mane, "Such as creation's dawn beheld, thou rollest now." Byron had wandered in poetic revery amongst the vestiges of ancient empires, and sighed to think how the greatest works of human genius dissolve to dust. He had saddened, perhaps, at the thought of his own inevitable fate, and fancied that in the "deep and dark blue ocean" only, could be discerned "the image of eternity." Had Byron learned that the seven hills themselves, on which had sat imperial Rome, were but the vestiges of an older order of things, and that even solid continents have crumbled like the Coliseum, a deeper tinge would have colored his habitual melancholy. Happy had it been for Byron could he have practiced the belief in the existence and eternity of his own spirit which he sometimes confessed; for there is nothing but spirit which bears "the image of eternity."

The "everlasting hills"—the fancied types of solidity and endurance—are but a passing phase in the history of terrestrial matter. The mountain's sullen brow has frowned where quiet vales expand themselves to the morning light, and fields and cities smile where rugged cliffs and abysmal gorges long delayed the advent of a race that had been heralded through the geologic ages.

Even continents have their lifetime. They germinate; they grow; they attain to full expansion and beauty; they fulfill their mission in the economy of matter and of life; the furrows of senescence channel their wasted faces, and they return to mud and slime, whence they were born. The very substance of the solid floors which underlie the soil of American freedom, is but the dust of continents decayed. As modern cities are sometimes built from the ruins of ancient temples on whose sites they stand, so the dwelling place prepared for man by the hand of Nature is but the reconstructed material of a more ancient continent, the work of Nature's "'prentice hand." The vertical thickness of fifty thousand feet of sedimentary strata measures the depth of the rubbish accumulated from mountain cliffs and continental slopes that have been transformed by the wand of time. We sometimes forget that the total volume of our stratified rocks is but an index of the denudations and obliterations that have been wrought. Much calcareous material has, indeed, been yielded by the sea; but the sea first filched it from the land.

The revelation made by every formation which we study, from the bottom to the top of the Paleozoic series, points to the north and northeast as the origin of the stream of sediments that spread over the bottom of the American lagoon which stretched as a broad and shallow ocean from the rising, but yet submarine, slopes of the Alleghanies on the east, to the embryonic ridges of the Rocky Mountains on the west. Northeastward of the present continent have undoubtedly existed supplies of incalculable magnitude, of which but the merest vestiges remain. The geologist leads us to the region north of the great lakes and the St. Lawrence River, and points out the Laurentide Ridge as the nucleus of the eastern portion of our continent. Around its bases has been wrapped layer upon layer of accumulating sediments.

till the ocean has been banished from a broad belt of his ancient dominion. But this, instead of being the real nucleus of the American continent, is but the vestige of that nucleus.* How vastly inferior in height and breadth, and especially in northeastward prolongation, to that primordial continent whose crumbling shores and denuded slopes afforded material for the broad sheets of Silurian, Devonian and Carboniferous strata which stretch a thousand miles in every direction! Where lay the dissolving lands which furnished substance for the ponderous Alleghanies? It must be that vast areas have disappeared from view. Though we believe, with Dana, that the modern continents were outlined in primeval time, and the ocean still reposes in his ancient bed, we must not be too exact in the enunciation of our faith. The Aleutian Islands, stretching from Alaska across the North Pacific, are but the protruding vertebræ of an eroded ancient ridge which welded the Orient to the Occident. New England, Gaspe, the Labrador elbow—these all reach toward the site of an obliterated prolongation—a friendly arm of the American continent stretched out to greet the continental arm of Europe extended from the British Archipelago toward America. Newfoundland, Cape Breton, Prince Edward's, Anticosti—these are but the highest summits of that wasted ridge, as Ireland and Great Britain are the relics of the ridge responsive to this upon the European side. The submarine plateau, along whose back creeps the great Atlantic Cable, though sunken ten thousand feet beneath the reach of further denudation, is but the stump of an ancient continent that has been gnawed to the very foundations. It is interesting to reflect that advancing civilization has at last re-established the amicable intercommunication of two continents, which had been embraced, perhaps, in the ordinations of primeval time.

Such are the reminiscences of a wasted continent of which the Laurentide nucleus is but a trace. We stand upon this venerable relic of long-forgotten lands, and the current of time sweeps by, bearing upon its dark bosom the wrecks of other continents born of earthquake and flood in the later ages of terrestrial history. But though we intend to rescue from oblivion the tales inscribed upon these disappearing ruins, thought lingers fondly and reverently and inquiringly around the scorched and beaten brow of this Laurentide Ridge. What was its mother? And where was its birth-place? These ancient granites and thickly-bedded gneisses—thrice baked and crystallized by the fiery ordeals through which they have passed—bear, nevertheless, the ineffaceable traces of old ocean's work. Here are the lines of sediment which betray the parentage of these hardened and storm-beaten rocks. Back into another cycle of eternity imagination plunges in search of that more ancient land that was reconstructed in this "primordial" ridge. To say that it did not exist, is to say that old ocean could pile up masonry without a supply of bricks and mortar. In the realm of thought, that earlier land looms up; but its bounds and borders are obscured by the overhanging fogs which haunt the early twilight of time. The skies themselves are strange, and our science gropes for the data which shall fix the latitude and longitude of this undiscovered land. Was it still another pile of rocks reared by the labors of water? Or was it a mass of ancient slag, the first-born products of primeval refrigeration of a molten globe? There was an earliest land—a dome of lava just cooled from the fiery abyss of molten matter—a film of frozen dolerite or porphyry stretched around the fluent globe—a solid floor on which descended from the gathered clouds the waters which formed a sea without a shore.

There must have been a time when the surges were first summoned to their work. To assert, with Hall, that it is idle to dream of such a beginning, because, forsooth, the traces of the morning's work have been obliterated by the operations of mid-day, is to plunge into the fallacies of the too fashionable nescience philosophy, and to assert that there is no knowledge but that which the senses certify.

We turn now our thoughts down the stream of time, and note the relics of later revolutions. Not for eternity were laid the floors of the Old Red Sandstone strata which once stretched, perhaps, from the Catskills to Massachusetts Bay. Not for eternity were reared the Appalachian summits whose elevation celebrated the close of Paleozoic time. The Catskills are but a pile of horizontal strata, spared by the gigantic denudations which scraped the face of New England to the bone, and washed away a third of the Empire State. The continuation of the Catskill strata is discovered again in Pennsylvania, Western New York, Ohio and Michigan. Who shall undertake to delineate the topography, the drainage, the vegetation, the populations of that ancient New England surface which now lies strewn, perhaps, from the bottom of Long Island Sound to the further shores of Jersey? Who shall write an epic on the fortunes of that mythical forefather land? The summits of the Alleghanies, geologists tell us, have settled down some thousands of feet. Their huge, protruding folds, plaited together in compact array, have been planed down to their innermost core; and from the chips have been produced the lowlands of the south Atlantic border—like the water-front raised in a modern city by carting down the sand-hills in the rear. The very coal-beds interwoven in their stony structure are but the fossilized swamps of an ancient continental surface that has disappeared—clothed once by forest trees whose family types have dropped from the ranks of existence, and populated by those strange amphibians—half fish, half reptile—which, like the fabled Colossus, bridged the chasm between two dominions.

There was a long and mediæval time in American history of which our records are mostly lost. The coal lands had been finished; the atmosphere had been purged; the Appalachians had been raised, and from their bases stretched westward beyond the destined valley of the Mississippi, an undulating upland but lately redeemed from the dominion of interminable bogs. The western border of this land skirted a mediterranean sea, through which probably the Gulf Stream coursed from the tropics to the frozen ocean. Here was accumulated a soil; here descended genial rains; here flourished tropical plants; and here wound majestic rivers, fed by their hundreds of tributary streams. All traces of this ancient continent have disappeared. Terrestrial animals must have populated the spacious forests; insects uttered their sleepy hum amid the luxuriant foliage of evergreen Voltzias, and sluggish Labyrinthodonts crawled from beneath the shade of perennial Cycads. This ancient home of vegetable and animal life spread over the States of Ohio and Indiana and Illinois and Kentucky, and all the region contiguous to these. River channels were dug, whose very locations we seek in vain. Cities and villages and verdant farms now stand upon the sites above which waved a sombre forest whose every trace has been wiped from the face of the continent, while the very soil in which their roots were bedded has been transported to the Gulf of Mexico. Those broad and fertile plains performed their part in the history of terrestrial preparations, and, like the pictures on the lithographer's stone, they have been completely erased, to be suc-

ceeded by the next scene in the succession of continental landscapes.

There was an ancient surface on which was growing the cinnamon, the plane tree, the magnolia, and other tropical and sub-tropical forest-growths. It stretched from the borders of the Atlantic to the slopes of the Pacific, and from the Mexican Gulf to the shores of the frozen ocean. It was the American continent, now first extending its limbs after a protracted embryonic growth. We are not positively informed whether, to the east of the Mississippi, this continent was the continuation, in time, of that which resulted from the changes closing the Carboniferous Age; but we well know, since Dr. Newberry's explorations, that in the far west, over the Colorado plains, was a vast region which had but recently emerged from the bed of ocean waters. Here lies the "great central plateau" of the continent, formed of vast, stony sheets, piled one above the other, which have never been tilted from their approximate horizontality since the beginning of Paleozoic time. And here, again, we are led to inquire, whence so vast an amount of sedimentary material, strewn through Paleozoic, Mesozoic and Tertiary ages, over the bottom of that broad continental ocean? Where now those wide-extended lands or towering mountain ridges whose dissolving substance yielded sand and cement for the Titanic masonry of a new-made continent? Wherever it was, and whatever it was, the "tooth of time" has gnawed it to a skeleton. It is a continent of the past, worn out by the uses to which nature has subjected every continental area in turn, and which to-day are wearing out and destroying the land on which, for the passing time, the human race, like those which have preceded it, has found a momentary foothold.

But the great central plateau, once freshly formed from the older lands which were exhausted in its formation, is, in turn, but the ruins of a former fruitful and smiling region. For nearly a thousand miles in breadth, and probably two thousand miles in length—stretching from the Mormon monarchy southward, far into the republic of Mexico—a frightful desert reigns. Naked rocks and thirsty sands, and shrubless, treeless wastes, are only diversified by yawning chasms and dismal *canons*, and Cyclopean walls rising in the distance from height to height, like the gigantic steps by which the monster Typhon scaled the realm of Jove. Once on a time a thousand mountain streams leaped down upon this plain, and gathered themselves by degrees together, and grew into the majestic Colorado, which glided quietly, or by occasional falls, into the Gulf of California—itself now shrunken to half its former dimensions. At intervals, expanded crystal lakes, turning their mirror surface toward the sun as cheerfully as ever smiled Lake George. The incumbent atmosphere drank copiously from the abundant waters, and returned its deluges of thanks in cooling summer showers. Thus herb and shrub and forest-tree rejoiced, alternately, in smiling sunlight and refreshing rain. The great central plateau was the prairie region of the continent. It was this, perhaps, while the region east of the Mississippi was lying a worn-out desert waste, unrenovated since the age which witnessed the elevation of the Alleghanies. But the ceaseless erosion of running streams, for thousands of years unnumbered, has sunken the water-courses of the central plateau to the depth of hundreds and thousands of feet; every lake is drained; the local supply of moisture has disappeared; the streams have withered in their ancient channels; vegetation has retreated to the mountain slopes; the giant Cereus alone rears its spectre form, like a ghostly visitant, to the graves of its former kindred.

There is reason to believe, that before the advent of the glacier epoch, nearly the whole of North America was a worn-out continent. It is possible, however, that most of the denudation of the central plateau has occurred during and since the prevalence of glaciers over the northeastern portion of the continent. As to the region east of the Mississippi, however, we know that it was an upland continental area, while even the rocky foundations of the great plateau were accumulating in the bottom of an ocean. It is difficult to conceive how this eastern region, on the advent of the glacier epoch, could have presented a surface less eroded and desert than that which the Colorado valley presents to-day. Vegetation, undoubtedly, held possession of the borders of the water-courses; and it must be remembered the conditions of atmospheric precipitation were, even at that time, as much superior to those of the arid western plains as they now are. Nevertheless, the local sources of humidity had mostly dried up, and the ancient rivers had sunken hundreds of feet, into dismal gorges, that were destined to be their graves. Traces of these fossil river channels are frequently encountered. Dr. Newberry has pointed out their existence in Ohio, and General Warren has more recently indicated their presence in Wisconsin, Minnesota and Dakotah. The latter has also shown that a depression of the northeastern region of the continent, which is even now in progress, has turned northward and eastward the drainage of Winnepeg and other lakes which once poured their surplusage through the Minnesota and Mississippi rivers.

The great glacier, in its movement over the surface of the Northern States, together with changes of level, and the action of torrents of water springing from the bosom of the dissolving ice-field, has totally transformed the face of this portion of the continent. The ancient river courses have been filled; the rugged, eroded and naked rocks have been re-clothed with fresh materials for vegetable sustenance; the surface is again strewn with streaming lakes; and plants and animals, and man himself, find, in the renovated continent, the fitting conditions of their prosperity.

But this last state of things can no more be permanent than that which has preceded. The present continent is destined to experience the symptoms of senescence and decay. Every year the untiring streams transport new portions of the land into the bottom of the ocean. The Alleghanies mingle their tribute to the sea with that which is yielded by the distant Rocky Mountains. From age to age the mountain tops are descending to the plain; the rounded hills are shrinking; the gorges are deepening; the changing vegetal growths are responding to the changing conditions; the present is passing away; once more the wrinkles of age will furrow the face of the continent, and the populous organisms which had found a fitting home upon it will exist no more. The valley of the Mississippi is no more fertile than was once the valley of the Colorado. We read in the present condition of the latter, the destiny which awaits the former. The slow but inevitable steps are in progress before our eyes. The "image of eternity" can be discerned neither in the ocean, which is but an instrument for the accumulation of solid land, nor in the rocky foundations of the land, which, from cycle to cycle, are re-wrought into the masonry of renovated continental surfaces. Man himself, who populates but one of these successive "time-worlds," is destined to yield to impending revolution. Human history is but a scene in the moving panorama of life, and its term is no less certain than that of the Mesozoic

saurians. It may be the last scene; we believe it is the last; but its limitations are inscribed upon the scroll of the geologic ages, and proclaimed in the events of the passing hour.

Neither can the series of continental renovations continue without limit. The time must come when the earth will be "in the sere and yellow leaf." The forces which hoist a continent dripping from the depths of a recent ocean will be weary of their labors. Already they act with greatly lessened energy. These, like all other forces, are seeking rest. Equilibrium and stagnation are the goal of all mechanical activities. Uplifted mountains, denuded continents, obliterated seas, appearing and disappearing races—these all are but the incidents of the progress of all terrestrial forces to a state of ultimate repose. Not only has nature fixed the limits of our race; she has equally staked out the duration of the present terrestrial order, and proclaimed in the ears of all intelligences that the flow of events which we trace so clearly to a remote beginning is destined, in the distant future, to be merged again in ancient chaos. So the perpetuity of cosmical order is not insured by the laws of matter alone. An omnific Arm begins, sustains, controls the evolutions of the successive cycles of material history.

SKETCHES FROM MEMORY—II.

BY DR. SIDEVIEW.

THE BLACK HOUSE AND ITS OWNER.—I think that first impressions, as to moral propensities, are the most reliable—that the first estimate of one's character, for good or evil, is the correct one. No matter what changes one's opinion may subsequently undergo, something is sure to occur, at some time, to remind one of that first thought—something to strengthen the confidence, or increase the distrust. So confident am I of the correctness of this theory, that I will make no exception.

Regarding the mental capacities, we may often err; for there is more complication, and more time is required for a proper estimate. We may tell good or evil at first sight, but we can not hope to judge of a person's abilities by casual acquaintance, except in rare cases.

In the spring of '57, business called me from York State to Fort Wayne, Indiana. I took the Lake Shore route to Toledo, changing cars there for Fort Wayne.

The coach that I entered was well filled, only one seat vacant, and not a very desirable one, at that. I took it, however, hoping for something better before I reached my journey's end.

Before the train started, a lady, plainly dressed and thickly vailed, entered the car. I waited with some curiosity to see who would offer her a seat, but not one of all that she passed was at her service. She walked the length of the car to the end where I was sitting, and I, almost ashamed of my sex, arose and gave her my own.

She sank into it so wearily that I looked at her again before I turned away. She lifted her vail and thanked me, revealing a face so pale and wan, that I wondered at her being there without an escort, or even at all.

There were deep grief-lines, too, in that face, from which I read a tale of

suffering, and the eyes were deep with melancholy; yet I detected a faint trace of joyful expectation in them, which gave me hope that the heavy burden was lifting—that the reward was near at hand. Ah! it was nearer than I thought, or hoped.

And this woman, this stranger, whom I had never seen before, impressed me with the belief that she was all that was good and true. I could see no sin, no wrong in that face, and I was moved to pity.

At the next station several passengers left the car, affording me a seat directly behind this lady; and thus we rode all the way to Fort Wayne, arriving there in the evening.

I arose to leave the car, but something peculiar in the position of the lady in front of me attracted my attention. I leaned forward and spoke to her, thinking that she might have fallen asleep, but she neither answered nor moved. I then drew aside the vail, and saw that she had swooned.

Calling for assistance, we removed her to the waiting-room.

"You are wasting your time and your pity," said a man—I will not call him gentleman—that had followed us from the car.

"She is sick, and a stranger in a strange city," I replied.

I think he felt the rebuke, but he replied, with assumed carelessness:

"She has brought it upon herself, and you will have your hands full if you minister to the wants of all like her."

Yet I could not doubt that face. No, not if all the world were against me. That there was wrong somewhere, I could not doubt; but she was only the victim.

I applied restoratives, and she revived. I then had her conveyed to a private house—I have never forgotten the Christian family that took her in—and procured every possible comfort, and the best care that could be found.

I prolonged my stay in the place far beyond my first intentions. The poor woman looked upon me as her best friend, and surely I could not leave her. How small a matter for me, but how great to her!

I remained until all her earthly troubles were over, following the mother and the child to one grave.

From her own lips I learned but little of her past life—not enough to clear away the doubts; yet I held to my first impression. A feeling of sadness comes over me now, as I write of her, and think what might have been. The trusting love, the patience, the courage, the self-denial of this woman, has few equals. Yet it could not be avoided. A similar case may not be found once in a thousand lives, and I pray it may not. But it left its blight, the broken heart, the earthly misery, only to be canceled by a happiness beyond the grave.

"You will find him?" she said, when she knew that the end was near.

"I will."

"You will tell him that I was on the way? Tell him that I never blamed him?"

"I will."

"And you will bid him good-by for me?"

These were her last words.

I did find him, and I told him all.

I traveled by rail as far as I could. Then I procured a horse for the remainder of the journey.

The directions that she gave me were not very distinct, therefore I was obliged to ask my way.

"It is just twelve miles from the corporation line to the northeast corner of the forty acres. Drive yonder to the red barn; take the left across two eighties; angle across another eighty—all belongs to Kidd—and you'll come out to what we call the quarter-line school-house. Take the north and south road for two miles, then cut across the peraira till you strike the section-line,

THE BOULDER OF 1869.

THIS stranger to our precincts—appropriated and adopted by the class of 1869—has traveled hither from the far north. It is probable its home, for many ages, was upon the northern shore of lake Huron. There it was wrenched from its ancient fastenings by a geologic convulsion—seized in the grip of the glacier—borne three hundred miles over obliterated river and lake, and relinquished, at last, within sight of the future temple of western learning. Here it has lain for perhaps a hundred ages, awaiting the advent of the class of 1869, and its final installation in the University as a voiceless lecturer on the history and mutations of the world.

This traveled rock—to those who can enter into communion with it—recites a tale of varied adventure. It is a rock of much more than usual interest. It is a rock of rocks. It is not the stone of which the contemptuous could say

"A stone is a stone and nothing more."

It is an epitome of petrology—it is a lithological museum—it is geological science converged to a focus—it is a table of contents of the Book of Nature. Let us look into it.

This interesting rock is a heterogeneous conglomerate containing about seventeen cubic feet, and weighing, consequently, about three thousand pounds. Whatever angularities it possessed when first venturing from home, have all been worn off, by contact with the world. On one side may be discovered not only the polish due to the action of the glacier, but also one or two distinct furrows scored into the flinty substance of the rock.

The constituents of the conglomerate vary in size from grains of sand to fragments four or five inches in diameter. Most of these are themselves rounded and worn by some ancient conflict with geologic forces; but a few preserve still a rounded angularity. The constituent pebbles present a lively assortment of colors from black to greenish blue, drab, rose-color, red and white. The surface of the boulder intersects these various-colored pebbles without regard to hardness, quality or complexion. It thus presents a diversity of colors wor-

thy of some of the dashing patterns of modern calicoes. Indeed this rock—long familiar to all travelers over the "middle Ypsilanti road"—has always been known as "the calico rock"—and it is not impossible that this name gave it a charm in seniors' eyes.

In studying carefully the composition of the boulder, I have recognized no less than twenty one varieties of rocks and minerals: 1. *Chlorite rock*, a soft, homogeneous, bluish-green material, in fragments an inch or less in diameter. This is also called melaphyr by some writers. 2. *Chlorite Schist*, in somewhat angular slaty fragments, on one side exposing a layer of about a square foot in extent. 3. *Chloritic scales*, or white crystalline chlorite. 4. *Mica* (muscovite) in scattered scales. 5. *Argillite* of a reddish color, in limited amount. 6. *Red Jasper* in small quantity. 7. *Black Jasper* in smaller quantity. 8. *Orthoclase* in detached broken crystals, and as constituent of numerous pebbles. 9. *Porphyrine*, in numerous fragments of a homogeneous, reddish color. 10. *Petrosilex*, moderately abundant, and very hard. 11. *Glassy Quartz* in detached fragments of the size of a marble and less. 12. *Rose Quartz*. 13. *Smoky Quartz*. 14. *Silicious Schist*. 15. *Granular Quartzite*. 16. *Quartzose Grit*. 17. *Quartzose Conglomerate*. 18. *Granulite*, with abundant deep red orthoclase. 19. *Granulite* with abundant pale red orthoclase —the last two and the second named, constituting half of the bulk of the boulder. 20. *Gneiss*, in limited amount. 21. *Pyroxenic Gneiss*, in greater abundance.

The boulder illustrates, moreover, the phenomena of 1. Massive structure. 2. Schistose structure. 3. Gritty structure. 4. Pudding stone. 5. Semi-breccia. 6. Glacial polish. 7. Glacial grooves. 8. Glacial transportation.

Here are not less than twenty-nine geological phenomena set forth by the teaching of a single stone.

But this is not all. It is a revelator of unseen and impalpable facts. It speaks a history. In contemplating this lost rock, we are led to think of the modern epoch, during which it has lain exposed upon the surface of the earth—beaten by a thousand wintry storms—the witness of the life and history of the savage tribes which pursued their game or fought their battles among the hills and vales of the "beautiful peninsula." And then we think of the time when it was first transported

to this region, and picture to ourselves the wrestling and the crashing of the great glacier along a journey of three hundred miles, and continued over a period of a thousand years or more. And next, we ask where the glacier picked it up, and under what circumstances it found our boulder existing. It may have wrenched it from a projecting crag. It may have found it a fragment torn by an earthquake convulsion from its parent bed. But the parent bed—where was that, and what had been its history? There was, and probably still remains, an extensive formation of rock, of which the glacier has brought us this specimen. There was an older time, then, when the powers of geology in their untamed energy, were engaged in bringing together from twenty shores the materials which were to enter into the constitution of that mother formation. Who shall discover the shores whence they were gathered? They are the ruins of a continent which nourished the growth even of the Eözoic continent—the growth even of the *germ* of North America. Into the dim horizon of eternity sink the desolate undiscovered shores of that first-born land. But it existed. Nor was that even, the beginning. Imagination is called upon to take another flight into the retreating ages of terrestrial history. This granulite—this gneiss—this chloritic schist—these are themselves products of sedimentary deposition which went forward during an age anterior to the time when these rocks were bluff-bound shores yielding débris for our conglomerate. If the constituents of these were not themselves ground from some still more ancient beach, they show at least that old ocean existed, and was even then occupied in laying down courses of sediments—even if pure chemical precipitates—which were destined to be rewrought into rocks that should stand to the age of man.

Perhaps the visible testimonies of our boulder go no further. But they have given thought an impulse which refuses to be arrested even at this limit. She demands what sort of a sea-bottom that primeval ocean rested upon. Was it also a bed of rock that had been accumulated in an ocean? If so, upon what sort of a bottom did that older ocean rest? There must have been an ocean, in the history of the world, which rested on a floor of refrigerated lava. There must have been a *first* ocean. To deny it is to deny that our globe has been in progress of cooling from a natural beginning. To deny it is

to assume that its history began in the midst of an evolution that, under the laws of Nature, is as likely to have had antecedent as subsequent terms. It is to deny that the earth has been cooling as long as physical laws render possible. It is to *assume* that it was created in mid career instead of at the commencement of it. It is a suicide of the positive philosophy which makes the denial, since, by denying the existence of an antecedent molten condition of the globe the positivist postulates a creation at a point where creation was not necessary—obtrudes the ever incomprehensible miracle of creation at a juncture when he must perform another miracle by interrupting the spontaneous course of Nature.

So builds reason on the foundation-stones bound up in this boulder. Even from this rock we mount into the past eternity, and grope for that beginning which was the source, the fountain—*bereshith*—whence flowed naturally the stream of events which we trace, by the lamp of science, down through the geologic ages, and witness, even to-day, rushing like a mighty tide before our eyes, and bearing man himself along, with all his works, into the abyss of future years.

And when thought reaches this limit, she finds herself confronted by an adamantine wall. Beyond this is only Omnipotence; and while the deep utterances of the soul of man speak ever of primary causation, reason discovers here that Primary Cause. This is the response of science to the intuitions of the soul. This is the triumph of the soul when science falls disabled. This is the harmony between Nature and Mind; this is the unison of Philosophy and Faith.

Thanks, from the depths of the heart, that this ancient, war-worn boulder, smitten by the wand of science, has opened such a permanent fountain of God's eternal truth.

A. Winchell.

OUTLINE

OF A

PROPOSED FINAL REPORT

OF A

SURVEY OF THE STATE OF MICHIGAN

TO BE MADE IN PURSUANCE OF

AN ACT APPROVED MARCH 26, 1869.

BY ALEXANDER WINCHELL,
DIRECTOR.

ANN ARBOR:
Dr. Chase's Steam Printing-House, 41 & 43 North Main Street.
1869.

NOTICE.

THE following Outline is placed in print, for four reasons. *First,* It is desirable for every officer and employee of the Survey to have before him "a plan to work to." This shows what is to be done; and what it is every man's duty to help in accomplishing. *Second,* It is deemed appropriate to announce to such as interest themselves in the Survey, what is the nature of the results which we hope to attain. They will thus be in a condition better to appreciate the importance and value of the labor. *Thirdly,* It is designed to solicit suggestions. If the plan is defective in any respect, or too full in others, it is hoped that suggestions will be freely offered. *Fourthly,* This announcement makes known to every one what facts and information are desired; and every one is hereby earnestly requested to co-operate by sending specimens and information. All aid received will be scrupulously acknowledged.

It may appear to some that topics herein embraced do not legitimately belong to the Survey, as constituted. Such, perhaps, are Parts VIII., IX. and X., and some portions of the Vth Division of Part I. Of all the subjects, it may, however, be said:—1. A large store of facts is already in our possession, which have never been worked up. 2. The store of facts will be greatly increased without any additional expense. 3. No other provision exists for working up these subjects. 4. They are intimately connected with the public interests of our State. 5. The law establishing the Survey requires "an investigation of the soils and subsoils, and a determination of their characters and agricultural adaptations"; and the Final Report must contain an exhibit of the "nature, location, and extent of the geological and *agricultural* resources of the State." 6. This plan has received the sanction of the State Executive and other good judges.

It will be noticed that the economical aspects of the Survey are made peculiarly prominent. The Director is determined that plain men shall be able to see how careful observations, made according to scientific methods, can become interesting to themselves and a fund of information to all seeking acquaintance with our State. If science really *cannot* command the respect of the agricultural and mechanical masses, it is certain that she is not worthy of it.

OUTLINE.

INTRODUCTION.—Historical Sketch of the Progress of Geology in Michigan.

PART I.

PHYSIOGRAPHIC FEATURES OF THE STATE.

I. GEOGRAPHICAL POSITION AND AREA.

II. HYDROGRAPHY.

1. Lakes.—(1) Description, (2) Origin, (3) The Fisheries, (4) Navigation.
2. Streams.—(1) Descriptive Enumeration, (2) Navigation, (3) Water Power.

III. TOPOGRAPHY.

1. Relation of Topography to Geology.
2. Hypsometrical Data. (Altitudes and Depressions.)
3. General Configuration of the Surface.
4. Marshes, Alluviums, &c.—Their Origin and History.
5. Prairies and their Origin.
6. Denudation of the Terrestrial Surface.—Its causes, amount and utilities.

IV. CLIMATE.

1. Relations of Climate to Habitability.
2. On what Conditions Climate depends.
3. Meteorological Data for Michigan.
4. The Climate of Michigan compared with that of other Regions in the same latitude.
5. Exceptional Character of our Climate and its Causes.

V. THE SOIL AND ITS PRODUCTS. [*For the Origin of Soils and their Geological History, see Part III.*]

1. The Forest.

(1) Succession of Forest Growths.

(2) Influence of Forests on Climate.

(a) Destruction and Renovation of Forests and their effects.

(b) Public efforts to preserve and Reproduce Forests.

(c) Disappearance of the Forests of Michigan.

(3) The Character and Distribution of our Forests.

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[It is thought unnecessary to present the details of the plan under this and the following heads. The Marquette Iron District is undergoing a thorough investigation in pursuance of a detailed plan, by Maj. T. B. Brooks, Assistant.]

PART V.

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[The Survey of the Copper region will be taken up next year by a competent geologist.]

PART VI.

DETAILED GEOLOGY OF THE STATE BY COUNTIES AND DISTRICTS.

[This part will give the last results of a minute survey. Geological Descriptions will be extended over every township.]

PART VII.

PALEONTOLOGY OF THE STATE.

[Many results have already been elaborated in this part; and not a little has already been published in the scientific journals. It remains to gather the results together, to complete the investigations and to present them, with suitable illustrations, to our citizens and to the world.]

PART VIII.

ZOÖLOGY OF THE STATE.

[Much, in this department, has already been done, and much more will naturally be accomplished in the progress of the Survey. It is hoped the State will cause the work to be completed.]

PART IX.

BOTANY OF THE STATE.

[See remarks under Part VIII.]

PART X.

ANTIQUITIES OF THE STATE.

[See remarks under Part VIII.]

From E. W. Hilgard
5 Sep. 18

From the American Journal of Science, Vol. XLII, May, 1866.

ON THE

QUATERNARY FORMATIONS

OF THE STATE OF MISSISSIPPI.

By EUG. W. HILGARD, Ph.D.,
State Geologist of Mississippi.

In my Report on the Geology and Agriculture of Mississippi, printed in 1860, I have given my observations on the Quaternary formations of this state. (See pp. 5 to 46, and 194 to 201, incl.) I now desire to present some general considerations on this subject, which in the place referred to could find but a brief mention or discussion. In so doing I shall not reiterate in detail the facts and observations recorded there, but in mentioning them will refer the reader to the corresponding paragraphs of the published volume. Having been for several years past deprived of all scientific intercourse, I desire to enter beforehand a disclaimer as to any intentional plagiarism, should some of the views and questions here presented have been meanwhile discussed and perhaps settled by others.

I have stated (§ 326) that, aside from the Alluvium proper, attributable to causes still in action, there are four distinct stages of the Quaternary recognizable in Mississippi, to wit:

1. The "Orange Sand."
2. The Bluff or Loess.
3. The "Yellow Loam."
4. The "Hummocks," or Second Bottoms, which I shall consider in the order of their age.

The Orange Sand.—I am not aware that a formation of precisely the same *ensemble* of character as this, exists outside of the States of Mississippi, Alabama, Tennessee, and small portions of Louisiana, Kentucky and Arkansas. Its existence in the latter two states is apparent from observations recorded in various places in the reports of the geological surveys of Arkansas and Kentucky; more especially does the description given by Dr. Owen of Crowley's ridge, Greene county, Ark., agree closely with the usual facies of the formation as observed by myself in Mississippi, and by Prof. Safford in West Tennessee. In Alabama it

is characteristically developed in the northwestern portion of the state, on the waters of the Buttahatchie, Looxapalila, and Sipsey. It is not specially so described in Tuomey's Alabama reports, from the accidental circumstance of his never having personally visited that portion of the state, which afforded no prospect of important practical discoveries; but I have traversed the region in 1856 on a visit to Tuscaloosa, a few months before Prof. Tuomey's untimely death.

Prof. Safford, in his First Biennial Report of the Tennessee Survey (p. 162), classes his "Orange Sand Group" as a member of the Cretaceous formation; without, however, claiming as final results, this as well as other opinions derived, as he himself states, from a mere reconnoisance. Having been unable to procure a copy of his later report, I am not aware whether or not, on reëxamination, he had changed his views on this point, as I have no doubt he would upon a fuller investigation of the facts of the case, such as they force themselves upon the attention of a geological observer in Mississippi.[1] From the few data given by him *l. c.*, though they can leave no doubt as to the identity of the formation, I am unable to judge whether the "bed of greensand" mentioned by him, together with the underlying lignitic clays, are referable to the Ripley and Eutaw Groups or to the "Northern Lignitic" of my report, which as there stated (§ 166), is sometimes glauconitic in its highest member. The greensand of McNairy Co., Tenn., is unquestionably Cretaceous; Safford's Lignite Group is, doubtless, the continuation of my "Northern Lignitic"; but he has failed to identify the Orange sand with the "Drift series" underlying the Bluff formation on the edge of the Bottom. Considering the highly complicated relations often existing between the Orange Sand and the underlying Cretaceous strata (as exemplified §§ 33 to 40, *et al.*), the occurrence of Cretaceous fossils in the ferruginous sandstone capping the hills, and the appropriation of Cretaceous material, almost unchanged to the formation of strata most unequivocally connected with the Orange Sand, the misapprehension of Prof. Safford is extremely natural. It requires, indeed, all the closeness of research which necessity imposes upon the geologist in Mississippi, to convince one's self of the identity of this capricious formation under all its forms, the knowledge of which I am even now far from satisfied of having exhausted.

The Orange Sand, as my observations show, overlies in Mississippi formations reaching from the lowest Sub-carboniferous slate (Saff. 1st Rept., p. 158) through the Cretaceous and Tertiary to a group of deposits on the Gulf coast, which so far I have found to contain only living species, and am therefore inclined

[1] Prof. Safford refers the beds to the Tertiary in this Journal, xxxvii, 361, May 1864, in an important paper treating of the "Cretaceous and Superior Formations of Tennessee."—Eds.

to consider of Pleistocene (or Quaternary?) age (§ 247, and ff.). All over this area, it contains, more or less, the fossils of the underlying formations, mostly *waterworn;* while the closest scrutiny I have bestowed on hundreds of extensive exposures, has failed to detect any fossil apparently peculiar to the formation as such. This might seem paradoxical enough to any one acquainted with the frequent occurrence of silicified wood in these strata; but it soon becomes quite obvious to an attentive observer, that the regions of frequent occurrence of this fossil in the Orange Sand, are coëxtensive with those in which fossil wood, either silicified (when imbedded in siliceous sands) or lignitized occurs in the underlying lignitiferoüs (Cretaceous or Tertiary) strata. It is not at all unusual to find trunks of silicified wood imbedded partly in the unchanged lignitic strata, partly in the Orange Sand; the portion contained in the latter being nearly or wholly deprived of carbon, while the part imbedded in the lignitic material is, if at all silicified, of an ebony tint, and often contains pyrites (§ 26, *ad finem*).

While, therefore, I admit the possibility of a further specific determination of these silicified trunks assigning to the Orange Sand some peculiar species, I am convinced that the greater part, if not all of this fossil is derived from the underlying strata, and will be found represented in their flora. Wherever silicified wood does occur at a distance from lignitiferous deposits, it forms waterworn pebbles; and not unfrequently, layers of comminuted fragments of the same, form the line of contact between the older strata and the Orange Sand. (See for example, § 169, section 17.)

The lithological and stratigraphical characters of the formation, however, (which in the absence of proper fossils must form our landmarks), are strongly marked, and the correspondence of many of its prominent features with those of the deposits of the Drift proper in the northwestern states, as described by Dr. Owen, Profs. Hall, Swallow and others, is manifest at a glance. The materials are essentially correspondent, and disposed in a similar manner; proving the action of violent currents and their concomitants—extensive denudation of the more ancient formations, appropriation and re-deposition of their materials with the irregularity of arrangement consequent upon the alternate existence of currents, eddies, slack water and counter-currents, in one and the same place.

The geographical distribution of this formation, as well as the total absence of any observable dips, where its strata are sufficiently continuous to admit of such determinations, clearly prove its deposition posterior to the epoch of upheaval which has given a sensible dip even to the latest Tertiary (if Tertiary it is) of the Gulf coast (§§ 250, 869). The main body of the formation

seems to represent an immense delta, whose apex is in the neighborhood of the junction of the Ohio and Mississippi. Its *eastern* outline descends along the ridge of Carboniferous rocks skirting the Tennessee valley on the west, and passing along the western outline of the coal-measures of Alabama, reaches the Warrior river at or above Tuscaloosa. Thence the formation extends southeastward toward the Coosa, but the pebble belt which generally so far has marked the eastern outline, seems to follow rather the course of the Warrior and Tombigby coastward. In Alabama, however, as in Mississippi, it is but thinly represented on the territory of the "Rotten Limestone."

The extreme western outline of the delta is, doubtless, to be sought in Arkansas, skirting on the east the high lands of that state. That the great channel of the Mississippi, however, was already impressed upon the surface at the time of the deposition of this formation, is rendered obvious by the existence in it, parallel to that channel, of a belt of pebbles and coarse shingle, which at present reaches but a short distance (ten to fifteen miles) inland from the "bluff" or edge of the great bottom. It was deflected westward by the Tertiary ridge of the "Walnut Hills," abutting at Vicksburg upon the Mississippi, the latter having almost entirely cut away the pebble deposit; it reappears, however, below Grand Gulf, and thence again has spread southeastward across the state, so as to reach, in Marion Co., Miss., the waters of Pearl river.

While the Mississippi river is thus the legitimate modern representative of the great ancient current which was capable of transporting such coarse material, no *one* channel now remains to represent the corresponding stream (or bayou, as it would now be termed) on the eastern edge of the delta whose existence in times past is certified by a similar band of pebble deposits now crossed in several directions by the drainage of the country it traverses. Unlike the loose beds of the western band, those of the eastern stream are often, if not prevalently, cemented into solid pudding-stones by a cement of brown iron ore; which circumstance may give some clue to the deflection of the waters from the ancient channel which now, on the contrary, forms a dividing ridge between the waters of the Tennessee and upper Tombigby.

Such being the general disposition of these deposits, we are led to inquire into the origin of the great inundation of water apparently devoid of organic life, by which they were formed. What traces of its existence has it left north of the latitude of the Ohio, whence the rush of waters evidently came? The northern geologist may pertinently retort: "What became of that rush of waters whereof our Drift furnishes the evidence, after it left our latitudes?"

Given, the Northern Drift: it appears to me that the *Southern Drift* is a postulate, so far as the surface confirmation of the United States would admit of its deposition. And here we have a formation possessing, as we shall see, all the main features of the northern Drift, the differences being quantitative rather than qualitative—its age later than the latest Tertiary, yet anterior to the Loess. There are but two essential features to distinguish it from the beds of the northern Drift proper. These are, first, the absence, or at least, great scarcity of "erratic blocks" proper, *i. e.*, of fragments of rocks derived from distant localities and not, or but slightly, waterworn; secondly, the great prevalence, to the extent of characteristic feature, of limited deposits of ferruginous sandstone or conglomerate, which, however small their local extent, have by their resistance to denudation controlled the surface conformation of by far the greater portion of the State of Mississippi (§ 11 and ff.).

As regards the former point, it would seem to find a ready explanation in the *lower latitude* in which these deposits are situated. Whatever may have been the precise nature of the "Drift agencies," it cannot be doubted that arctic ice, whether icebergs proper, or shore-ice floes, were instrumental in the transportation of the sharp-angled fragments we find imbedded in the northern Drift deposits, innocent equally of the rounding action of water, and of the grinding and scratching one of glazier transportation. It is but rarely that at the present time, the floating ice of the Mississippi river passes much beyond the latitude of Vicksburg; and it is difficult to conceive how even the largest berg should not, before reaching a latitude so low, have performed so many evolutions through the successive changes of its center of gravity, as to have dropped every vestige of moraine material. Yet some stout floe of shore-ice might be supposed to be capable of reaching this latitude without dropping all its passengers, some of which might be therefore expected to occur amongst the (otherwise invariably waterworn) materials of the southern Drift. And such in fact is the case, for, however rarely, a few large angular boulders *have* been found in the Orange Sand of Mississippi (§ 21). The block of milky quartz in the collection of the University of Mississippi, shows a surface almost as sharply angular and splintery as if freshly broken from its original place.

As to the second point, it amounts to a mere quantitative difference as to the extent of the process which, from Minnesota to the Gulf coast, forms ferruginous sandstones, claystones and conglomerates of various degrees of hardness, in the deposits of the Drift period. While in those of the northwest, the ferruginizing process has played but a subordinate part, and within the limits of the Drift itself, in Mississippi its action has frequently extended beyond the Orange Sand, into the underlying formations.

It has thus, for example, metamorphosed the white, leaf-bearing clays of the Tertiary, into the fine-grained ferruginous shales whose species have been in part determined by Mr. Lesquereux (§ 170, Sec. 18). Where the clays are less siliceous and consequently less pervious, the ferruginous solution, unable to penetrate, has aggregated into nodules of limonite ore (§ 42). On the territory of the Carboniferous, the ferruginous conglomerate of hornstone pebbles (which passes through all gradations of fineness into the common ferruginous sandstone of the hilltops) is underlaid by a singular hornstone breccia, whose adjacent angular fragments mostly fit each other, as though produced by the contraction in drying, of a gelatinous mass. The cement of this breccia is brown iron ore which fills the interstices and has colored to the depth of one-tenth to one-eighth of an inch, the substance of the hornstone fragments. (See also § 72, and note.)

These phenomena, when considered in connection with the abundant occurrence of ferruginous sands and sandstones in the upper members of the group, seem to be characteristic of the *end* of the period of its formation; for no such tendency to ferrugination is observable in the overlying formations of the Bluff and Yellow Loam, whereas the principal deposits of ferruginous sandstone or pudding-stone invariably occur at the *highest* levels, both geologically and hypsometrically of the Orange Sand deposits.

* As to the occurrence of silicified wood, its presence in the beds of the Drift of Iowa is repeatedly mentioned by Prof. Hall; it also occurs, I believe, in the southern counties of Missouri, and in Arkansas, though not, as far as I am aware, to the extent it does in Mississippi, where in some regions, entire logs of this fossil (sometimes with part of the roots and branches) are of common occurrence. They are, however, always prostrate. I have attempted to trace to its origin the report mentioned by Prof. Wailes (First Rept. on the Geology of Miss., p. 282) of a silicified tree found standing upright with its roots in place; but it has always receded before me and vanished like a mirage. I have myself found trunks imbedded in the Orange Sand at a considerable angle with the horizon, a fact as easily explained as the discordant stratification of the formation, but which to inexperienced eyes might seem the next thing to seeing them growing there.

Yet it is hard to believe that even the violent currents and eddies, of which the irregular stratification gives evidence (see *e. g.* Pl. II, fig. 2), should have been able to transport, or elevate to the summits of the highest ridges at times, bodies of such enormous weight; even though those same agencies have doubtlessly tossed up to similar elevations the limestone fragments containing Cretaceous fossils, whose calcareous ingredients have

* It is questionable whether this silicified ... belongs to the drift. It is more likely to

since been replaced by brown iron ore (§ 33). The conclusion seems inevitable that, when transported, these logs were either in a fresh, or semi-lignitized condition, such as we now find them in the subjacent lignitic strata; and that their silicification took place within the Orange Sand after its deposition. In my Report (§§ 15, 16, 44, 45,) I have given facts sufficient to prove that an abundant supply of silex has been active in this formation, which has given rise to the hard, non-fossiliferous sandstones found in it, and even to the silicification of beds of lignite *in situ* (§ 45).

That this process is still in progress seems to be proved by the disintegration, not only of hornstone pebbles (§ 32), but also of silicified wood itself; the inside of the trunks consisting frequently of translucent hornstone, while the outside is opaque, porous and sometimes (§ 44) asbestiform or pulverulent. One of the results of this process is, necessarily, the formation of siliceous solution, which in its turn may be active in effecting pseudomorphoses.

As regards the existence of the southern Drift in other southern states besides those above mentioned, the subject is discussed at some length in Tuomey's second Report on the Geology of Alabama, pp. 144 to 147; elsewhere, so far as I know, it is but incidentally mentioned. He refers to the existence of a long ridge of similar accumulations parallel to the Atlantic coast, apparently upon the margin of the ancient Tertiary (Pliocene?) sea; and he identifies the detrital strata upon which the cities of Baltimore, Washington, Richmond, Petersburg, Va., and Columbia, S. C., are situated, with the Tuscaloosa beds—which in their turn, are most unequivocally connected with the Orange Sand of Mississippi. With the latter formation he was acquainted only through my verbal communications, nor was I myself at the time, aware of the features of the formation on the large scale, or of the existence of the great delta whose apex reaches the confines of the northern Drift in Illinois and Missouri. Tuomey's doubts as to the connection between the two great divisions were therefore natural, but cannot now, I think, be sustained. Even though the waters of the northern Drift period were able to surmount, or rush through the passes of the Alleghany upheaval, they would not transport any materials beyond it; those forming the Drift of the eastern cotton states must of necessity be derived from the southern slopes of that barrier itself, as Tuomey states is the case in Alabama, and as I have found it to be in the eastern, and smaller, pebble belt of the Orange Sand delta in Mississippi. But where, as in the main channel of the Mississippi, those waters might rush southward unchecked, through the gap between the Alleghany and Ozark upheavals, we might expect to find traces of rocks derived from higher latitudes. Such are fur-

nished by the rare, small, and well-worn pebbles of greenstone, porphyry, trappean rocks and even mica schist, which close observation will detect among the shingle of the Mississippi-band; the direction of whose currents alone seem to forbid the derivation of these rocks from any point as far south as the eruptive and primary region of Arkansas. It remains for future comparisons, however, to settle this point.

As to the finer materials of this formation, it is significant that while the *sharpness* of the sand of the northern Drift deposits is often mentioned by writers on the subject, the sandgrains of the Orange Sand proper—that which forms the rocky hill-tops and the main body of the formation, are always very much *rounded*, as a proof of their transportation from a long distance. Whether or not the same is true of the Atlantic ridge of detritus mentioned by Tuomey, I am not aware; but it does not seem to have struck that observer.

Dr. D. D. Owen repeatedly mentions lignites and leaf-bearing clays of *quaternary* age, as underlying these deposits in Kentucky and Arkansas. Without calling in question the determination of that eminent observer, I will state that I have found no reason to suspect any more special connection between the Orange Sand and any of the lignitic beds of Mississippi, than is afforded by the obvious appropriation of the materials of the latter by the former formation—a relation existing equally where other formations underlie.

According to Mr. Lesquereux's determination, the lignitic of North Mississippi is certainly not newer than the Miocene; while some marine shells occurring in its highest strata, would seem to place it even below the lowest marine Eocene of the state (§ 162, ff.). While so far as my observations reach, I find no reason to suspect that all the lignitic strata occurring north of the marine Tertiary in Mississippi and Alabama, are not of the same age, I have nothing to urge against the occurrence of quaternary lignites elsewhere. Some of the lignitic beds of the Mississippi bluff (§ 181), of which I cannot speak from personal observation, may be of that age, as well as the small basin mentioned (§ 27) as occurring in a section of Orange Sand in Tennessee. In the absence of pretty *numerous* determinations of fossil plants, however, it must be difficult to decide upon the age of such strata, when not seen in juxtaposition with the marine Tertiary.

The Bluff, or Loess Group.—This stage of the quaternary formations does not offer, within this state, any features requiring special remark. From Vicksburg southward, it skirts the left bank of the Mississippi river, with a width, inland, of twelve to fifteen miles. It caps most of the high points visible from the

river, the maximum thickness observed being about seventy-five feet. It is usually underlaid by some member of the Orange Sand, and this in its turn by the sandstones or clays of the Grand Gulf group (§ 236 *et al.*). The chief difference between the Loess of Mississippi and that of Indiana, is the greater fineness of the material, and the total absence, as far as observed, of any but terrestrial fossils.

Apart from a few scattered sandgrains and calcareous concretions, it is a mouse-colored or buff, almost impalpable siliceous silt, but very lightly cemented by from 6 to 10 per cent of carbonate of lime. Like the Loess of Kentucky, it contains, also, a large amount (5 to 7 per cent) of carbonate of magesia.

Helix, Helicina, Pupa and Achatina are the genera thus far found in it. As to the mammalian bones, they are here, as in Kentucky, found chiefly not in the usual material of the formation, but in a "blue clay," which, however, I have not thus far had an opportunity of examining in place. I should here state that the Mastodon bones mentioned by Tuomey as having been found in the "Drift" of the lower Tombigby and Alabama, were by himself, upon reëxamination, referred to the Bluff, and *not* to the Drift or Orange Sand age.

Above Vicksburg, the Loess deposits appear along the edge of the Bluff, skirting the bottom, in irregular patches or narrow strips, such as would be exhibited below Vicksburg, were the main body of the formation, riverward, to be cut away. Such undoubtedly has been the case here, for in Tennessee, according to Safford, it is again found regularly skirting the bottom, many miles in width. It seems also that, as we advance northward, the color and fineness of the material changes, so as to resemble more and more that comprising the Loess of Indiana and Ohio.

No other river exhibits, within the state, any traces of the Loess along its course, so far as the latter is independent of the Mississippi river. The Big Black simply crosses the Loess region; the Tallahatchie and Yazoo simply touch it by accident, as it were. Neither Pearl river nor the Pascagoula, show any signs of it; while according to Tuomey, both the Tombigby and the Alabama river exhibit it characteristically, in the lower portion of their course. It would be interesting to study the circumstances which determine this apparently capricious selection. From the predominant horizontality of the lines of contact between the Orange Sand and Loess, it would seem that the deposition of the latter was not preceded by any very extensive denudations into the surface of the former; the Loess thus indicating, apparently, those channels which during Drift period, formed the main outlets of its waters.

The Yellow Loam.—Next in the upward order, and as distinctly superimposed upon the Loess where it exists, as it is else-

where upon the Orange Sand,[1] we find a deposit consisting usually of a mellow brick clay, or loam, more or less ferruginous, and subject to inconsiderable variations in accordance with the character of the underlying materials. It might in some regions, therefore, be accounted a mere surface disintegration of older strata, but for the fact that in others it is distinctly developed as an independent stratum; its maximum thickness observed being about twenty feet, while the average lies perhaps between five and ten.

As to its geographical distribution, it is not a little remarkable that, while the preceding and succeeding stages, viz., the Bluff and the Hommock deposits, show a very obvious relation to the drainage of the country, such is the case only to a very limited extent with the Yellow Loam itself, which seems originally to have overspread the country very evenly, with on the whole a slightly increasing thickness toward the larger channels, such as the Mississippi, lower Tallahatchie, Yallabusha, Big Black, and Tombigby. The local uniformity of its material, the absence of stratification-lines in its own mass, and the horizontality of its lines of contact with underlying formations seem to be incompatible with the existence of strongly denuding currents during its deposition; while at the same time, its distribution and other characteristics render equally inadmissible the supposition of its being either a lacustrine or marine deposit.

The extensive denudations which *succeeded* its deposition render it extremely difficult to determine, in *all* cases, where this stratum is in its original place. It has disappeared, and unfortunately is still disappearing rapidly from many ridges, which according to their level as compared with adjoining regions, have been capped with it. Yet while it doubtless never was deposited upon some of the highest ridges of the state, which were above water even then, it is found manifestly *in situ* both on plateaus elevated above the general surface, and in regions a hundred or more feet lower, immediately adjoining the former. And since in all cases its character varies more or less in accordance with that of the underlying material, which enters into its composition and therefore testifies of a certain amount of denuding action, it would seem that the conditions of its deposition could be satisfied only by the assumption of the submergence of the surface under water locally deep, but always gently flowing—not sea-water, for the deposit is void of fossils—nor for the same reason, precisely such as that which deposited the Bluff formation. On the same ground, and on that of its inconsiderable thickness, we must also conclude that but a short space of time was occupied in its deposition.

[1] Or rather, upon an amorphous and ill-defined transition stratum of "hardpan," usually one to three, but locally as much as fifteen feet in thickness (§ 335).

It may be premature to attempt to define more precisely the nature of the events which attended the formation of this deposit. It may have been the result of the expiring efforts of the Drift waters to find their way over the delta, whose surface, after deeply eroding it, they had elevated by flooding it with detritus. But there is one point requiring mention as intimately connected with the subject; I refer to the peculiar constitution of the *prairies* of Mississippi and Alabama.

These differ in several essential features from the prairies either of Illinois or of the Plains. They are not usually altogether treeless, but possess a sparse growth of stout, well formed, compact Black Jack and Post Oak, with occasionally a Red Cedar; except where the Cretaceous limestone is within a foot or two of the surface, causing "Bald Prairies" with only scattered clumps of Crab Apple, Wild Plum, Persimmon, and Amorpha. Usually, the Cretaceous rock ("Rotten Limestone") is overlaid by a stratum five to twelve feet in thickness, of a material differing from the Yellow Loam of adjoining ridges only in the amount of lime and clay contained in it, and showing unequivocal transitions into the Loam stratum proper on the edge of the prairies, where on the hillsides similar material is formed, wherever the Cretaceous rock is in a corresponding position. Hence I consider the underclay of the prairies as the equivalent of the Yellow Loam, modified in its composition by the subjacent rock; just as, on broad sandy ridges, the Loam is sometimes represented by an extremely sandy "hardpan" (§ 651); or by the intractable "Hog Wallow" soil, where it is underlaid by certain stages of the lignitic Tertiary (§ 746).

As to the hypsometrical position of the Cretaceous prairies, it is not a very definite one. Locally they are surrounded by, and lower than adjoining ridges, but this is by no means the rule. Large bodies on the contrary seem rather to occupy the position of dividing plateaus, on a level, or nearly so, with the hill-tops of adjoining uplands. Their position, no less than their material, seem, therefore, to forbid attributing to them a lacustrine origin; while a comparison of the composition of the prairie underclay (§ 548) and of the Rotten Limestone (§ 149) will dispose of the idea of "surface disintegration."

There is another facies of surface conformation which seems to be parallel, not only geographically, but geologically and genetically, to the prairies, viz., the level belt of land timbered prevalently with Post Oak, and popularly known as "the Flatwoods" (§ 561, ff.). North of Ocktibbeha county, Miss., they are separated from the prairie belt by intervening ridges, but farther south the two trails coalesce, the difference of soil alone marking, in some degree, their confines. That difference is manifestly owing to, and parallel with, that between the subjacent

materials; which in the case of the flatwoods, is the heavy gray clay of the lignitic (§ 165), resisting denudation equally as much as the Rotten Limestone.

It seems to me that in this resistance to denudation is to be sought the cause, both of the absence of the Orange Sand deposits from both tracts (§ 6), and of their levelness, their surface being, as it were, parallel to that of the strata of the underlying older formation. (See profile, Pl. I, fig. 2, in Miss. Report.)

Wherever water can make little impression on the surface over which it flows, its motion is, *caeteris paribus,* more rapid, and its tendency to form deposits much less, than where a roughened bed gives rise to eddies and counter-currents, and every initial deposit induces the formation of others around it in a geometrical ratio of increase.

Whether we suppose the Orange Sand never to have been deposited on the prairies and flatwoods, or that it has subsequently been removed; its absence is to be accounted for. We cannot for a moment suppose that the waters which deposited the Orange Sand did not visit the region, since the ridges which divide the prairies and flatwoods are thickly capped with it (§§ 122, 137), and bands of Orange Sand frequently divide from each other adjacent patches of prairie land. When this is the case, although the surface may be on a level with the prairie, the Cretaceous limestone is always much deeper underground. And it is equally obvious, in passing westward from the flatwoods, that they disappear as soon as the stratum which has served to form their characteristic soil dips too low, and is overlaid by the more easily denuded materials of the lignitic (§ 587).

Considerations quite analogous to these apply also to the Tertiary prairies of South Mississippi, and the adjoining "Hog Wallow" or "Post Oak" prairie—the latter possessing no better claim to the title of prairie than the flatwoods of North Mississippi. There are but few cases in which (as in some of the prairies of Scott Co.) the subsoil can be considered a mere surface disintegration, if we confine the meaning of that term to the changes attributable to atmospheric influences alone, as should be done. Whenever the material has been transported from its original place, breaking up its structure and stratification, it must be considered a distinct deposit, no matter whether or not its chemical composition has undergone a change.

How far similar considerations may apply to the prairies of Illinois, in connection with the Carboniferous strata, those better acquainted than I am with the facts of the case must determine. It would seem to be a postulate of the ingenious theory of Mr. Lesquereux on this subject, that the Drift period should have left them greatly more level than we now find them, and if my memory serves me, the deposits of the Drift proper are but feebly represented in the level portions, the material covering the Car-

boniferous rocks being analogous, apparently, rather to the Yellow Loam of Mississippi and Alabama.

The sparseness of the timber on the prairies of Mississippi does not, as it seems to me, present any difficulty of explanation. All over the state, the Black Jack and Post Oak are the chief denizens of upland soils of extreme physical conditions; hence their prevalence on the heavy prairie soil. Owing to the luxuriant growth of grass, etc., on the prairies, but a small percentage of the most vigorous seedlings can escape the annual fires. These, however, from the fertility of the soil and the free scope for development afforded by their sparseness, can naturally become exquisite specimens of their species (§ 545).

In the "Flatwoods," *per contra*, while the species of trees selected would be the same, the exceedingly scant growth of grass would not seriously impair, in burning, the abundance of young trees. Hence we find on them a dense growth of lank, poorly clad trees, the very type of their species when occupying an illiberal soil (§ 568). Precisely the same relations, as regards their timber, existed in the uplands of the Yellow Loam region (§ 606) between the Black Jack ridges and the fertile Table-lands (611, 616), when both were regularly burnt by the Indians. The former possess a dense growth of gnarled, tattered trees, the latter had the appearance of artificial parks—now marred by the dense undergrowth which the omission of burning, or burning at the wrong season, has allowed to spring up (§ 796).

The "Hummocks," or Second Bottoms.—While the period marked by the Yellow Loam and its equivalents must have presented features not now exemplified, called forth by causes which have ceased to act, the formation next in upward order differs from those now in progress only in the quantity or intensity of the action which produced them.

The Second Bottoms form part of the valleys of all the larger streams of the state, and in some districts even of the "creeks." They are in general most extensive where the material of the adjoining uplands was most easily denuded (without being too pervious, as in the Pine Hills of the south (§§ 32, 77), and has therefore permitted the excavation of wide valleys; while, where that material resisted denudation, the contraction of the valley and consequent greater swiftness of the stream have either prevented the formation of these deposits, or caused their subsequent removal.

There are two points of difference between these "second bottoms" and the "first bottoms" of the present era, which enable the observer to distinguish them even when either is entirely absent. In the first place, the "hummock" is always out of reach of the highest water within the memory of the "oldest inhabitant," and in many cases the first bottom is as distinctly cut into the second bottom deposits, as the water channel is into the first

bottom, there being a *sudden* ascent of from three to as much as ten or more feet, while by a more gradual slope, thereafter, the difference of level often amounts to twenty feet and more. In the second place, not only is there almost always a decided difference between the materials, and consequently the soils and natural vegetation, of the first and second bottoms of one and the same stream (for example, § 809), but the nature of the latter soil shows a certain correspondence all over the state, so as to be mostly recognizable at a glance by an experienced eye. It is only in the lower portion of the course of the larger streams, that this distinction is lost in a great degree.

The soils and subsoils referred to are mostly pale gray or buff-colored, fine siliceous silts, with but little coarse sand, accompanied by *irregularly* shaped concretions of bog ore: very unretentive, and poor in phosphoric acid and lime. Their character varies measurably in accordance with the materials of the bordering uplands, whereas the first bottom soils are chiefly dependent, for their character, upon the materials into which the bed of the present stream is cut. Beneath the subsoil, we find the materials stratified precisely in the manner described by Prof. Swallow with reference to the "Bottom prairies" of Missouri, to which I have no doubt they are equivalent, as well as to the "river terraces" described years ago in this Journal (by Dr. Newberry, I believe,) from observations on the valleys of Ohio. There is but one serious point of difference as regards the former, viz., that the Bottom prairie contains the fossils of the Bluff formation, whereas the hummock deposits of Mississippi, as far as known, present but a very few and indistinct stems and leaves, occasionally, in the more clayey bands. But it must be considered, that neither is the Bluff formation itself represented on the streams in question. It therefore remains to be determined whether those fossils are an essential characteristic of the Bottom prairie, outside of the region of the Bluff formation, and on the smaller streams I have not thus far succeeded in discovering any fossils in the somewhat equivocal deposits which seem to represent the "second bottom" epoch near the mouths of the Big Black, Bayou Pierre, Homochitto and other streams, on the territory of the Bluff formation. And as to the existence of any representative of that epoch in the great Mississippi Bottom itself, I have not had any opportunity of observing.

It is evidently during the period of the Second Bottoms that the great denudations which have traced the valleys of our water-courses of the second, third, and even fourth order, were accomplished by agencies considerably more energetic than those operating at present. It was then that the sketch was made of the map whose more delicate tracery and shades the alluvial epoch has since, and is now working out. Unless we assume a somewhat *sudden* transition, a more or less *abrupt* remission of

the denuding agencies, it is difficult to understand why there should be any terraces of the kind described—why they, with their easily denuded material, should not have attained a gradual slope of surface toward the channel, instead of being as level as the first bottom itself. To my mind, the era represented by the second bottoms appears as distinctly marked as that of the Bluff formation, and as much entitled to a distinctive *name* recognized everywhere. The difficulty of the study of the quaternary formations, sufficiently great of itself, is greatly enhanced by the want of such terms, and the failure on the part of many observers, hitherto, even to attempt to parallelize in different localities the formations more recent than the Loess. If I am not greatly mistaken, the Yellow Loam, also, is as distinctly represented in Illinois and Missouri as it is south of the Ohio. Then why should not the "Loam period" and that of the "River terraces" be as distinctly recognized among American geologists as those of the Drift and Loess? Even if these divisions were not recognizable outside of the Mississippi valley, they would serve a good purpose for the study of not a small portion of the earth's surface.[1]

Since writing the above, I have received from Prof. Winchell a copy of his interesting remarks on the subject of the apparent northward transportation of large boulder deposits in the Drift of Michigan. While appreciating the force of his reasoning as regards those deposits, all my observations in this state and such portions of Alabama as I have visited, contradict the assumption of any northward transportation amongst the materials of the Drift. The steady decrease of the "grain" of transported materials as we advance southward, provided the evident direction of the transporting currents be taken into account, is an insuperable obstacle to that supposition as far as the Orange Sand is concerned. Of the "red loam" mentioned by him I cannot speak from personal knowledge, though I presume it to be identical with the material found in corresponding positions in Mississippi. If so, I cannot agree with Prof. Winchell as to its being a mere surface disintegration of the Rotten Limestone "altered *in situ* or with slight transportation." It will be seen by a glance at my map of the formations of Mississippi, that in view of the change of direction in the strike of the Cretaceous strata, the geographical position of the "red loam," supposing it to be essentially connected with the Rotten Limestone, can be accounted for equally as well by the assumption of southeasterly, as of northerly currents. That is precisely the direction indicated, as above stated, by the trend of the eastern pebble band of the Orange Sand delta.

University of Mississippi, December, 1865.

[1] The epoch here referred to as deserving a name is that designated the *Champlain*, in Dana's Mineralogy (p. 547), from deposits of the era upon the borders of Lake Champlain called the Champlain formation by Prof. C. H. Hitchcock.—Eds.

5 Sept, 1870

[FROM THE AMERICAN JOURNAL OF SCIENCE, &c., XLII, Nov., 1866.]

Remarks on the Drift of the Western and Southern States, and its relations to the Glacier and Iceberg Theories.

BY EUG. W. HILGARD, PH.D.,
State Geologist of Mississippi.

IN a recent paper on the Quaternary formations of Mississippi (this Journal, May, 1866), I have expressed my views concerning the remarkable formation designated as the "Orange Sand," in my Report on the Geology of Mississippi.

The admirable exposition of the whole subject of the Post-tertiary formations in Dana's Manual of Geology, to which I have since been enabled to refer, as well as the portion of Dana's Address before the American Association in 1855, relating to that period, suggest to me with greater clearness the points to be settled in establishing the presumed correspondence of the Orange Sand of the Southwest to the recognized drift of the Northwest. On this subject I now propose to offer a few additional remarks.

I have not perhaps, in the paper referred to, been sufficiently explicit, in comparing the Orange Sand to the northern drift in general, without specially mentioning as its supposed congener, the drift of the Northwest, particularly that of Illinois, Wisconsin, Iowa and Missouri. That the drift of New England, as described by Hitchcock and Dana, can be satisfactorily accounted for on the glacier theory alone, few who have delved among the ancient and modern moraines of Switzerland will question.

But the Western drift deposits, even so far north as Iowa, as Hall's observations show, and still more in Illinois and Missouri, differ seriously in their structure both from the New England moraines, and from the lines of blocks apparently left by the glacier melted *in situ*. In the West the "erratic" blocks, both rounded and angular, are commonly found imbedded in deposits distinctly stratified over considerable areas, and consisting of gravel, sand, or even clay; and the pebbles accompanying them are not the irregular, scored and scratched forms of the moraine pebble, but clearly rounded by aqueous action.

Where a moraine has not, subsequently to its formation, been violently shoved forward by an unusual advance of the glacier, some semblance of stratification may occur, in consequence of great regularity in the rolling down of the detritus. But such

an appearance rarely extends connectedly beyond a few yards, nor is it likely it ever should, however stupendous the scale of the glacier. Nor will any one, acquainted with moraines and their material, be likely to mistake an aqueous deposit for a moraine, or *vice versâ.*

In Desmoines county, Iowa, according to Hall, the drift consists of "partially stratified deposits of clay, sand and gravel, with boulders of primary and secondary rocks irregularly distributed through the mass, though usually most abundant in the lower portion." These boulders in the description of Lee county are spoken of as "worn and rounded masses" of various rocks, occurring in distant localities. We have the same in Henry county; in Van Buren, this deposit furnished "a mass of siliceous wood," which "presented none of the water-worn characters of a boulder; but the angles were as sharp and well defined as if it had never been removed from the spot where it was at first buried." In Washington county, again, we find mentioned "a heavy deposit of drift material presenting the usual characteristics of this formation, and consisting of irregularly stratified beds of sand, gravel and clay, with an average thickness of from forty to sixty feet."

The above, taken *verbatim* from Hall's Iowa Report, might serve as a very fair description of a good portion of the Orange Sand of Mississippi, the only difference being the greater size of the boulders in the more northern locality; a merely quantitative variation.

In Missouri the phenomena are the same. The drift there, according to Swallow, is "a heterogeneous stratum" (but a *stratum* still!) "of sand, gravel and boulders, all water-worn fragments of the older rocks." Some of these are derived from localities as far distant as "St. Peters river, about 300 miles north of St. Joseph. But the paleozoic fragments are usually from localities near where they rest.... and are as *completely rounded* as those from more distant points."

The latter remark is interesting, as it shows precisely what I found to be the case in the eastern pebble belt of Mississippi. The pebbles there are almost exclusively derived from the siliceous group of the Carboniferous, which occurs only in patches farther northward, but underlies the pebble strata themselves (Miss. Rept., p. 17, ff.).

But Swallow goes on to say that "there are other deposits, particularly in the middle and southern parts of the State" (*sic!*) "which are not genuine drift, and yet they bear a greater resemblance to that than to any other formation, and occupy the same stratigraphical position."

This, also, is precisely the predicament of the Orange Sand deposits.

As for the drift of Illinois, I am unable to refer to the Reports of that State; but my own early recollections of it such as it exists in St. Clair county, place it in precisely the same category with the drift of Iowa and Missouri. Only I remember distinctly the occurrence in it, of *angular* boulders of syenite, greenstone and quartzite.

Nevertheless, most of the material by far, in all these cases, is *water-worn;* it is, more or less irregularly but distinctly, *stratified; no glacier scorings* are mentioned, either on the pebbles or on the adjacent rock.

The *glacier theory alone* cannot, therefore, account for these deposits north of the Ohio, any more than for the Orange Sand delta south of it. And even as far south as Vicksburg, the action of *water alone* is inadequate to account for the transportation of the boulders found in these beds.

Dana's remark (Manual, p. 554) that "while the glaciers were disappearing, many a stream or lake would have existed to stratify the drift, and cause denudation in elevated places," points no doubt to the true explanation of these phenomena: but it does not go far enough to satisfy existing facts. Agassiz has observed that "the melting snows of the declining glacier epoch" may have been instrumental in the formation of the river terraces; but Tuomey was, I believe, the first to point out, that the Southern drift may have been formed in consequence of the *sudden* melting of the northern glaciers (Second Report on the Geology of Alabama, ed. Mallet, p. 146); such as would have resulted from a first, rapid depression of so huge a mass of ice below the snow line.

The assumption of a pretty *rapid* depression seems necessary to account for the immense volumes of water required to produce the observed effects, and also to explain the possibility of inland transportation of boulders by floating ice—if indeed, after a depression of near 500 feet below the present level in the latitude of Montreal, *inland* it could be called. Though comparatively but slightly depressed at its mouth, the more immediate valley of the Mississippi would have formed a deep irregular gulf, filled with ice-cold water by the enormous influx from the glacier region forming its northern shore; whose icebergs would thus be floated southward in a medium unfit for the permanent existence of any fauna likely to be fossilized, viz: ice-cold fresh water in a state of violent flow.

That the action must at first have been extremely violent, is proved by the deep erosion of the underlying formations, and the transportation and subsequent redeposition in mass, of their materials, more or less altered; which is exhibited on so extensive a scale in Mississippi. But for the fact that wherever the

more ancient strata were readily susceptible of denudation, they have entered largely, at times almost exclusively, into the composition of the Orange Sand strata, we might suppose that the surface of the former (which appears to be at least equally as hilly as the present one) had been denuded by atmospheric agencies during the glacial period of elevation.

When, after the subsidence of the first rush, the velocity of the water had so far diminished as to render it capable of forming stratified deposits, these would naturally possess the mixed character resulting from a twofold mode of transportation—by water, and by floating ice—the former, no doubt, in many cases, succeeding the latter, and, by the grinding action of the smaller gravel and sand, transforming the angular blocks first dropped into the rounded boulders characterizing the drift of Iowa and Missouri, and faintly represented by their scattered congeners in the Orange Sand delta.

It would thus seem that the grandly simple means of a single elevation and re-depression in the northern latitudes, to which the phenomena of the ancient glaciers and sea-beaches point us, will equally satisfy the conditions required for the formation of the Western and Southern Drift. Down to the later stages of the northern re-depression, the predominant slope would everywhere be southward, so as to collect in the Mississippi valley the glacier waters, not only of the whole extent of northern territory now tributary to it, but probably also those of the present arctic slope of British America, and a portion of that now tributary to the St. Lawrence. Hence the comparative absence of stratified drift from the Northern Atlantic slope of the United States; and its presence, on the contrary, on the sea border of the Southern States, as stated by Tuomey, *l. c.*

As to the Champlain epoch, it would seem to be represented in its *later* part only, by that which in the Western and Gulf States has formed the "second bottoms." In the Mississippi Valley the formation of the latter has clearly been preceded by a period of comparative quiet succeeding the stormy times of the drift proper, and giving rise, successively, to the deposits of the Bluff or Loess, and the superincumbent Yellow Loam. These ought to be contemporaneous with the earlier stages of the Champlain epoch in New England and Canada; and their great difference of character might, it seems to me, be explained on the simple and probable supposition, that in the more southerly regions the depression took place somewhat later, even as, obviously, it was vastly less in extent. The Bluff formation of the valley of the Mississippi bears the most obvious relations to the present channels of the larger rivers, and it contains the vestiges of a fauna proving that the deluge of ice-cold water had

ceased; while yet the volume of water carried by those channels greatly exceeded that which corresponds to the era of the second bottoms, south, or to the bottom prairie of Missouri.

The only sea-beach terrace now existing on the Gulf coast, and with which the second bottoms show a manifest confluence of level and material, is from 18 to 24 feet above tide-water. But the evidences of sea-beach or tidal action extend far back into the interior (Miss. Rept. p. 29), so that in fact, the second bottom of the Pascagoula exhibits *that* structure, and not the usual one resulting from flowing water, throughout its course. The same structure, moreover, extends to some elevation into the bordering uplands, where these sands overlie the Post-pliocene beds and Orange Sand.

The present beach terrace of the gulf coast cannot, therefore, be considered as the true measure of the amount either of depression during, or re-elevation subsequent to, the Champlain epoch. Whether the great absolute elevation of some of the Orange Sand ridges of Mississippi and Alabama (probably exceeding in some cases, 700 feet) necessitates the assumption of even a greater depression than the present beach-marks would indicate, the known facts are hardly adequate to determine.

University of Mississippi, July 12, 1866.

[From the American Journal of Science and Arts, Vol. XLVII, Jan., 1869.]

ON THE

GEOLOGY OF LOWER LOUISIANA

AND THE

ROCK SALT DEPOSIT OF PETITE ANSE.

By EUGENE W. HILGARD, Ph. D.,

OF OXFORD, MISSISSIPPI.

(ABSTRACT.)

The discovery in 1862, of a deposit of rock-salt on the coast of Louisiana, was a fact so unexpected to geologists, that at any other time a detailed investigation of its geological relations would quickly have followed the first announcement. The pressing necessities of the blockaded section soon caused its exploitation on the large scale, though in a very irregular manner; for a considerable period, these mines supplied the whole of the southwest. In November, 1865, Prof. Richard Owen made a brief examination of the locality, the results of which he published in the Transactions of the St. Louis Academy. A year

later Dr. Charles A. Gössmann, under the auspices of the American Bureau of Mines, made an examination of the locality, mainly with a view to the exploitation of the deposit; his report, published by the Bureau, as well as the specimens which he courteously exhibited to me, confirm previous conjectures that the overlying strata were the equivalents of the formation I have described as the "Orange Sand" of Mississippi. I therefore gladly availed myself at the earliest possible moment, of the offer of the Smithsonian Institution to defray my expenses in making a detailed geological investigation of the region. The low stage of water prevailing at the time (December, 1867,) rendered it possible to observe to the best advantage the formations exhibited on the banks of the Mississippi; the examination of which, from Vicksburg to the Passes, was a needful preliminary step to the determination of the formations of the coast.

Having previously examined and described the sections exhibited at Vicksburg, Grand Gulf and Fort Adams,* I merely landed at some intermediate points to verify the conclusion previously reached, viz., that below Vicksburg, no marine formation crops out on the river banks, reports to the contrary notwithstanding; and that the profiles at Natchez, Rodney and other points are essentially similar to that at Fort Adams, where we find the strata of the (fresh-water) "Grand Gulf group" in a position nearly or quite horizontal; overlaid, first by the materials of the "Orange Sand," which in its turn is capped by the stratum of the "Loess" or Bluff formation, covered by a thin deposit of "Yellow Loam."

Facing southward from the "Blockhouse hill" at Fort Adams, we observe a wilderness of the characteristic sharp ridges of the Loess region, often fore-shortened into veritable peaks, elevated between 300 and 400 feet above the river. In this region, the Grand Gulf strata have been traced southward by Dr. George Little, the present State geologist of Mississippi, as far as the head waters of Thompson's Creek, northwest of Clinton, La.

The Orange Sand proper is visible, near the river, as far south as Jackson, La., but farther inland extends to a lower latitude. As for the Loess, it appears in full force and characteristically developed for some distance south of Fort Adams. But (according to Dr. Little's observations) these features become gradually modified as we advance southward. The Loess deposit thins out, its materials become poorer in lime and fossils, and assume more and more the character of a common fine grained "hardpan;" the transition being by insensible de-

* See Report on the Geology and Agriculture of Miss., 1860.

grees, while the two extremes are very obviously distinct. At the same time, the clayey substrata which, farther above appear only in patches (as at Nevitt's bluff, two miles above Natchez, as well as at the latter place itself) are seen more frequently and continuously, until, at Port Hudson, they become predominant.

The exposure at Port Hudson, previously examined in part by Bartram, Carpenter and Lyell, is about three miles in extent, from the mouth of Sandy Creek above the town, to Fontania Landing, 1½ miles below. Its lower half is washed, and continually encroached upon, by the river; its upper portion is now inland of an extensive sandbar. The strata are disposed horizontally or basin fashion, and vary a good deal both in thickness and materials, as shown in the subjoined profiles, situated about a mile apart; the correspondence of strata is ascertained by actual tracing of the stratification lines.

Near Sawmill, Port Hudson.	No.	*Midway betw'n Port Hudson & Fontania.*
Yellow surface Loam. 4—6 ft.	6	Yellow Loam, sandy below; 8—10 ft.
Yellow Hardpan, ... 25 ft.	5	White and yellow hardpan, ...18 ft. Orange and yellow sand, sometimes ferruginous sandstone, irregularly stratified, ...8—15 ft.
Heavy greenish Clay, ... 7 ft.	4	Heavy, greenish or bluish Clay, ..7 ft.
Gravel, sand and clay in irregular bands, like river alluvium; with pebbles, driftwood, leaves, and Mastodon bones, ...6 ft.	3	White indurate silt or hardpan, 18 ft.
Heavy, greenish or bluish, massy clay, similar to No. 4; 25 ft. visible.	2	Heavy green clay, with porous calcareous concretions above, ferruginous ones below; some sticks and impressions of leaves, ...30 ft.
	1	Brown muck, White or blue clay, } with cypress stumps, 3–4ft.

At the stage of extreme low water prevailing at the time, the stump-stratum No. 1 was visible to the thickness of 10 ft. at its highest point; showing several generations of stumps above one another, also the remnants of many successive falls of leaves and overflows. The wood is in a good state of preservation; no prostrate trunks to be seen at present.

The main clay deposit, No. 2, varies but little in general character; although very solid, its tendency to cleave into prismatic forms renders it very liable to "cave" into the river. The upper portion of the stratum, especially near its southern end, contains strings of calcareous nodules, on stratification lines eight to twelve inches apart. No fossils save rare impressions of leaves.

No. 3 is exceedingly variable. At the northern end of the outcrop, it is a narrow band of swamp deposit; at the first of the profiles given, it bears the character of a sandbar; lower down, it returns to that of a swamp deposit; still below, it is represented by a fine white silt, without a trace of vegetable remains. Lower down again, a lignitic layer appears at its base, with leaves and fruit of living species of lowland trees; while near Fontania, it is again a sandbar, with an abundance of prostrate trunks of driftwood, coarse sand and pebbles.

The green clay stratum No. 4 varies little, either in thickness or composition, and like the stump-stratum No. 1, forms a convenient level of reference.

The hardpan stratum No. 5 I conceive to be the more immediate representative of the Loess proper, with which it is connected by gradual transition, though at times greatly resembling some of the materials of the Orange Sand. It is void of fossils.

The present profile differs in many respects from those given by previous observers, which lay some distance farther west, where the river now flows. The strata are accordingly as variable in an east and west, as in a north and south direction, and with the exception of Nos. 1 and 2, are such as are now shown in ditches cut into the modern river-bottom deposits.

The stump-stratum No. 1, however, as appears from numerous data collected by myself or contained in Humphreys and Abbot's Report on the Mississippi river, exists at about the same level (i. e., near that of tide-water) not only over all the so-called Delta-plain of the Mississippi, but also higher up, perhaps as far as Memphis, and all along the gulf coast, at least from Mobile on the east to the Sabine river. Wherever circumstances allow, the overlying clay stratum No. 2, is also observed. These facts indicate the wide spread prevalence, during the epoch succeeding the drift, of quiet, shallow fresh-water lagoons and swamps of slightly varying elevation; through which the continental waters may for some time have found an outlet without a definite channel representing the Mississippi of to-day. The Port Hudson profile appears to be typical, its features being reproduced wherever denudation has not removed these deposits down to the level of the stump-stratum, as is mostly the case.

The Five Islands.

The chain of five islands rising partly from the sea, partly from the coast marsh, between the mouth of the Atchafalaya and Vermilion river, have been described by Mr. Thomassy,*

* Géologie pratique de la Louisiane; New Orleans, 1860.

who attributes their origin to "hydrothermal" or "volcanic" action. His descriptions are sufficiently faithful to show the general resemblance of their geological structure; so that after visiting the three middle members of the chain, viz: Côte Blanche, Weeks's Island, and Petite Anse, I have thought it superfluous to extend my examination to the two extreme ones, viz: Belle Isle, the promontory west of Atchafalaya Bay, and Miller's Island (or "Orange Grove,") overlooking the plains of the Vermilion. These elevations lie nearly in a straight line bearing N.W. by W. from Belle Isle.

Côte Blanche.

The next in order, affords on its sea-face a fine exposure of the lower members of the Port Hudson profile. At tide-level, we have the blue clay with cypress stumps, the tops of which are often surrounded by alternate layers of clay, muck and sometimes lignite. The overlying strata consist, partly of blue clay similar to No. 2 at Port Hudson, partly of various colored loams alternating with the former; and exhibiting the same calcareous or ferrugino-calcareous concretions along the stratification lines. At a few points, these calcareous concretions resolve themselves into distinct fossils, representing the fresh-water genera *Paludina*, *Melania*, *Unio*, *Anodonta* and *Cyclas*, in an indifferent state of preservation. The entire visible profile is about 50 feet high; the highest point of the island rises as high as 180 feet, but in its interior no exposures exist, so that the higher members of the series are not verifiable.

Weeks's Island.

This island, lying 6 miles N.W. by W. from Côte Blanche, has an area slightly greater, viz., 2,300 acres; it is nearly circular; maximum elevation 160 feet above tide water. Unlike Côte Blanche, it is traversed by deep ravines which exhibit the geological structure. In the central and highest portion, these gullies are bordered by steep slopes composed of the most characteristic materials of the Orange Sand group. On the exterior slopes, however, we find in a position inclined away from the center of the island, the lower strata of the Port Hudson profile—green or blue clay with calcareous concretions, and imperfect fresh-water shells. The blue clay stratum with cypress stumps is met with in ditching, and is also known to exist in the beds of the neighboring bayous, as well as in the surrounding marsh.

Petite Anse, or Avery's Island.

Petite Anse lies about 12 miles N.W. by W. of Weeks's Island, and in its general structure much resembles the latter, to which it is slightly inferior in size, and about equal in elevation; its highest point, "Prospect Hill," on the north side, being 160 feet above tide-level.

An elevated ridge connects Prospect Hill with another high point near the southern slope of the island; and near the west end a ridge, on which Judge Avery's house stands, falls off steeply toward the Bayou Petite Anse. These three points inclose the valley in which the salt deposit has been found and which opens southeastward into the marsh.

The topography of the island, as well as the history of the mine, have been ably given by Dr. Chas. A. Gössmann of Syracuse, in a report of the American Bureau of Mines.* Up to the time of his visit, all the pits and shafts had been sunk through detrital strata, washed down from the adjoining hills, and frequently inclosing the vestiges of both animal and human visits to the spot. Mastodon, buffalo and other bones; Indian hatchets, arrrow-heads and rush baskets, but above all an astonishing quantity of pottery fragments, have been extracted from the pits. The pots doubtless subserved the purpose of salt-boiling; human handiwork has, however, been found so close to the surface of the salt, as to render it likely that its existence in mass was once known, before the time when, in 1862, Mr. D. H. Avery struck the salt itself at the bottom of a salt water well.

The surface of the salt undulates considerably, so that borings commenced at different levels have repeatedly struck salt at nearly the same relative depth, the absolute level of the rock-salt surface varying from 32 ft. below to 1¾ ft. above tide level. The salt stratum has itself been penetrated to the depth of 38 feet, without any perceptible variation in quality; its "floor" being as yet unknown. Dr. Gössmann's observations and specimens proved to his and my satisfaction, the existence of the Orange Sand on the Island; but its relation to the rock-salt, and the age of the latter, remained undetermined.

Since then, another shaft has been sunk by Mr. Chouteau of St. Louis, with the assistance of Mr. Dudley Avery, to whom I am indebted for a record of the strata penetrated. This shaft was located at a higher level than any previously sunk, on a hillside where, not far off, the Orange Sand crops out *in situ.* After passing through these strata, the rock-salt was struck again, at a level several feet higher than on any former occasion.

* On the rock-salt deposit of Petite Anse, New York, 1867.

There can therefore be no doubt that the salt deposit is older than the Orange Sand, which here as at Weeks's Island, forms the nucleus of the mass on whose outer slopes, as well as its higher points, the strata of the Port Hudson profile reappear characteristically; with calcareous nodules, fresh water shells and aquatic plants identical with living species. Not only is the reference level of the cypress stump stratum the same as elsewhere, but the green clay band, No. 4 of the Port Hudson profile, is also there.

The stratigraphical disposition of these deposits is quite remarkable. They conform not to the *strata*, but measurably to the *outline* of the Orange Sand nucleus, roughly following its slopes and curvatures. At first sight therefore it seems as though a local upheaval had taken place, and hence arose, probably, the reports attributing a volcanic origin to these elevations, whose isolated position in the level coast region would naturally give rise to speculation as to their mode of formation. Indeed the extent to which these strata are sometimes seen to dip, rather staggers the observer; but the upheaval hypothesis does not explain the facts, unless we are content to assume a separate effort of the sort for every hillock on the islands.

There can be no doubt that subsidence subsequent to deposition has been the cause of the extravagant dips observed sometimes. Where the Port Hudson series is more immediately superimposed upon the Orange Sand nucleus, the dips are moderate, and such as may well be assumed as resulting from deposition on inclined surfaces. But when we see an apparently undisturbed clay-stratum moving down hill like a glacier, so as to overflow a deposit of loose stones, we need not go far to find the cause of extensive dislocation and subsidence.

Belle Isle and Miller's Island.

All the data I have been able to collect concerning the structure of these exterior islands, tend to confirm the probable supposition that, like the three interior ones, they consist of denuded nuclei of Orange Sand materials, upon which the Port Hudson series was afterwards deposited.

It seems likely that the same is true of a low ridge called Côte gêlée, in Lafayette parish, bearing N. or N.N.E. Thomassy places in the same category the Grand Côteau des Opelousas and the Avoyelles prairie.

Age of the Salt Deposit.

The Orange Sand strata so rarely approach the coast, that the deposits underlying them in the Coast region have scarcely

been observed with certainty. Even the older strata underlying the blue stump clay have been observed at a few points only, viz: by the Delta Survey in the bed of the Mississippi river at Bonnet Carré and Carrollton, near New Orleans; at the latter city itself, in the boring of wells; at Salt Point, on Bayou Salé; and on the coast of Mississippi Sound.

The strata penetrated in the borings at New Orleans are considered by Sir Chas. Lyell as Delta deposits. But according to my examination, they are almost throughout demonstrably of marine origin, and while the species they contain are mostly (not all) now known to be living on the Gulf coast, yet the prevalence of species is very different from that now observed near the mouths of the Mississippi. In this respect, the fauna of these strata shows a great analogy to those described as Pliocene by Tuomey and Holmes, occurring on the Carolina coast.

It is most probable that the rock-salt of Petite Anse will be found when pierced, to be imbedded in the equivalents of the deposits penetrated at New Orleans and Bayou Salé, and of corresponding, probably early quaternary age, anterior to the drift or its southern representative, the Orange Sand.

Origin and extent of the salt deposit.

The absence of layers of the usual impurities of rock-salt, especially of gypsum, has induced Dr. Gössmann to suppose that it is not the result of the evaporation of sea-water, but owes its formation to crystallization from the purer brine of salt springs.

Our knowledge of the facts is still too limited to render a discussion of this point very profitable. In a very deep lagoon, withdrawn from the influx of the tides after the brine had acquired a considerable degree of concentration, all the gypsum might be found in a single bed at the bottom; upon it a large mass of pure salt, as in the present case; while the salts of the mother-waters would naturally have been washed away from the top. Or there might have been a succession of lagoons communicating with each only during high tides, and acting in a manner analogous to the process now practiced in salt-making on the sea-shore. The gypsum would then all have been deposited in the outer lagoons, while the inner ones would have acted as brine-pits, where pure salt alone could crystallize. Crystals of gypsum have repeatedly been found in shallow wells on the coast, beneath the "stump clay."

Upon any of the foregoing suppositions, calling into play a variety of circumstances not likely to be all simultaneously fulfilled, it does not seem probable that the rock-salt mass is

very extensive horizontally, or that such masses should occur frequently in the coast region.

A mass of salt 144 acres in extent and 38 feet thick is, however, a handsome specimen, even if these dimensions should represent maxima. The great difficulty in mining it, heretofore, has been the influx of water through the gravelly strata overlying. But it has most probably been attacked, thus far, at its lowest surface level. Wherever elsewhere the Orange Sand formation prevails, it rests on a deeply denuded surface; and "hills within hills" are of very common occurrence. From the data thus far obtained it appears that the same is the case with the rock-salt mass, and that its surface roughly conforms to the hills and valleys now existing. Workings should be begun at higher levels; and it would not surprise me to learn that the auger had shown the mass to be accessible by level adits in lieu of shafts, on the hillsides. The interior of the solid mass once gained from a point secure from surface water, all difficulty would be at an end.

Geological History of the Lower Mississippi Valley.

It appears from the facts stated in the preceding pages, that after the termination of the epoch of that Eocene period, represented by the Vicksburg group of fossils, down to the Quaternary era, marine deposits ceased to be formed on the northern border of the basin now represented by the Gulf of Mexico.

I have acquired the certainty of the existence, over a large portion of northern Louisiana, of the "Grand Gulf" series of rocks. From specimens in the collection of the New Orleans Academy of Sciences, it appears that apart from the usual materials forming these beds in Mississippi, they assume in the Harrisonburg region the character of compact limestone, which in places is said to be fossiliferous, and would thus furnish the clue to the age of the Grand Gulf group, for which I have vainly sought in Mississippi. The problem is one of great interest, as it involves the question whether or not the Mexican gulf has, within comparatively modern times, been disconnected from the Atlantic ocean. The absence of the cauldron in which the Gulf Stream is concocted might have exerted climatic influences reaching beyond the American continent, and would explain many discrepancies between ancient and modern faunas on the shores of the Atlantic.

It appears that similar limestones, almost assuming the character of black marble, occur in St. Landry parish, near Opelousas. Whether the southern outline of the formation passes thence toward the Calcasieu region, where petroleum has been found, or whether it trends northwestward into the par-

ishes of Sabine and Natchitoches, where limestone and sandstone ridges also exist, is a question still open. In the latter case, this outline would conform to the general shore lines of the great cretaceous and tertiary Mediterranean.

In Mississippi, the Grand Gulf series is mostly overlaid by the Orange Sand, deposited on a deeply eroded surface, and bearing itself the evidence of its formation by fresh water in a state of violent flow.* The southern outline of the main body of the Orange Sand runs southward of Opelousas, toward the mouth of the Sabine, whence, according to reliable information, a broad band of shingle extends toward Harrisonburg, Catahoula parish. This belt represents, probably, the most westerly bayou of the great Orange Sand Delta; while, as heretofore stated, the most easterly one extends from the neighborhood of Cairo along the western shore of the Tennessee river, down the valley of the Warrior toward the coast of Alabama. The middle and main pebble-stream evidently follows in general the course of the Mississippi river; but leaving it at the point where that river suffers its remarkable deflection eastward, we find the remnants of its ancient "bar" in the chain of the "Fire Islands," which lie directly across the shortest line by which the Mississippi could reach the Gulf, and no doubt have had their share in causing this deflection.

Both the size of the pebbles carried by this middle bayou, and their character proving transportation from high northern latitudes, show it to have been the main channel during the Orange Sand epoch. It is not surprising, therefore, that in the direction of its course the Orange Sand formation should extend farther south than anywhere else. The pebble-beds are now overlaid by fine sandy materials, proving a diminished velocity, owing, doubtless, to a general depression, but greater at the north than at the south.

While the lateral bayous descending through Louisiana and Alabama were closed at the end of the Orange Sand epoch, it is evident that the central channel continued open; inasmuch as the next succeeding deposit, viz: the Loess, lies in a trough-shaped depression of the Orange Sand materials, the line of contact being always conformable and devoid of any trace of atmospheric denudation. The perfect peroxydation of the materials of the Orange Sand would seem, nevertheless, to point to a certain period of exposure to atmospheric agencies, caused by a temporary diminution of the influx of northern waters, through the cessation of subsidence, perhaps.

During this epoch of quiet might have begun the formation of those extensive swamp and lagoon deposits, the lower mem-

* Am. Jour. Science, May, 1866; Miss. Rep. 1860, p. 26 and ff.

bers of the Port Hudson series, whose floor stratum, with its superimposed generations of cypress stumps, indicate a slow secular subsidence. The velocity of the latter seems gradually to have increased until the growth of old trees became impossible, and finally, in stratum No. 3 of the Port Hudson profile, we again meet the evidences of currents moving sand, pebbles, and drift-wood.

Then follows the Loess proper, a deposit utterly devoid, in Mississippi and Louisiana, of any evidences of fluviatile action —a uniform silt even in profiles of 80 feet, with scarcely a vestige of stratification, and none but terrestrial fossils.

The precise circumstances under which such a deposit could be formed, are perhaps a little obscure. There must have been such a depression of the whole country as to transform the immediate valley of the Mississippi, as far as Keokuk, as well as the valleys of the larger tributaries, into estuaries of the Gulf of Mexico, containing a mass of water too great to be sensibly affected by the variations now causing the annual overflows of those rivers (for otherwise the deposits must have shown lines of deposition), yet possessing a gentle flow above (since the materials of the bluff formation of Missouri and Indiana exhibit signs of fluviatile action); quite fresh in its upper portions (where fluviatile shells are found), but rendered unfit for the life of either a fresh or salt-water fauna by an admixture of sea-water, in its lower and almost stagnant portion, at tide level; and deriving its vestiges of animal life only from the "offscourings" of the adjoining unsubmerged lands.

Sir Chas. Lyell* inclines to consider the Loess as the product of "successive inundations of a great river," the absence of stratification from such deposits having, apparently, an analogue in the alluvial deposits of the Nile. But the case is far from being analogous; for the same phenomena are still observed in the modern deposits of the Nile, and are clearly attributable to the peculiarities of the hydrographic basin of that river; whereas, in the modern alluvium of the Mississippi, it is exceedingly difficult to find a uniform stratum two feet in thickness. The Nile mud is each year derived from the same rivers of Abyssinia, and equalized by intermixture and subsidence during at least 1,500 miles of its course. On the Mississippi, on the contrary, the deposits of different annual inundations are readily distinguished by the inhabitants for years afterward, according as the Illinois, the Missouri, Ohio, Arkansas or Red river happen to have furnished the main influx. The absence of any such differences from the Loess can only be explained on the assumption that the mass of

* Principles of Geology, 10th edition, p. 464.

water filling the channels was too great to be sensibly affected by such causes, the more so as the continental surface was sensibly diminished in consequence of a depression which, as far south as Fort Adams, cannot have been less than 400 feet, and on the coast not less than 200, but more probably the same as farther above.

The existence of the elevations on the Louisiana coast, above described, renders it necessary to assume that at the end of the period of depression—the "Champlain epoch"—the entire delta-plain (so-called) west of the Mississippi was covered by the deposits of the Orange Sand and Port Hudson series to an equal height; and that during the succeeding "Terrace epoch" of elevation, the veritable Mississippi—*our* Mississippi—swept away these deposits in excavating its present valley. At first it might sweep over or through the pebble ridge, but would finally turn to the direction of least resistance, leaving the "Five Islands" high and dry.

It would thus seem that, unlike other large rivers of the world which have from the outset added to the land by bringing down the materials to form their alluvial plain, the Mississippi has first formed by denudation the plain which it was subsequently to cover with its alluvial deposits to a comparatively inconsiderable depth. The western and southern limits of this denuding action would seem to be marked by the Grand Côteau des Opelousas, the Côte Gêlée and the Five Islands; and the materials swept away from this area doubtless contributed largely to form the foundations of the truly alluvial plain extending south and southeastward of lakes Maurepas, Pontchartrain and Borgne.

It is obvious how futile must be all attempts to estimate the age of the Mississippi river in absolute measure, by a comparison of the advance of its present delta into the Gulf, with the distance of its mouth from the divergence of bayous Plaquemine or Manchac. When the broad flood of the Terrace epoch contracted into the present Mississippi, that stream emptied into a sea rendered shallow by the deposition, within a comparatively short period, of a huge amount of material. Within such a sea its channel would be likely to change about, somewhat like those of the great rivers of China. *Now*, it is advancing into the deep water of the Gulf of Mexico, but at a very different rate, and by a very different process from that of simple alluvion. But the questions pertaining to this portion of the subject, together with the results of my observations in the Delta proper, I propose to discuss at a future time.

5th Sept.

[FROM THE AMERICAN JOURN. OF SCIENCES AND ARTS, VOL. XLVIII, NOV., 1869.]

Summary of Results of a late Geological Reconnoissance of Louisiana; by EUGENE W. HILGARD, of the Univ. of Mississippi.

THE geological reconnoissance of a large portion of West Louisiana, the results of which I propose briefly to discuss, was made under the auspices of the New Orleans Academy of Sciences. The means required for outfit and traveling expenses were provided partly by subscription (chiefly among the members of the Academy), partly by an appropriation, made in furtherance of the object in view, by the Board of Immigration for the State of Louisiana. The time at my disposal for the purpose was, unfortunately, limited to thirty days; but in view of the presumable close correspondence of the formations of Louisiana to those of Mississippi, previously well known to me, as well as the information already in my possession as the result of a previous exploration made under the auspices of the Smithsonian Institution, I was led to anticipate that even a rapid reconnoissance would enable me to determine with sufficient precision, the chief characteristics and geographical outlines of the formations. I was accompanied and materially assisted by Dr. J. K. Walker, of New Orleans, a Fellow of the Academy, and Mr. Scott Miller, of the same city, who volunteered to take charge of the pack mule needed to carry specimens. The entire distance traversed on horseback was 625 miles, and the route was so chosen as to cross the presumable strike of the strata, as often as possible, while touching the most important known points of interest. Passing by the interesting chain of islands previously examined by me (Petite Anse, Côte Blanche, etc.), the party proceeded from New Iberia on the Tèche viâ Opelousas to Bayou Chicot, where the border of the older formations was reached; thence west to the Calcasieu river, down that stream to Lake Charles and the sulphur and petroleum wells on the West Fork of the Calcasieu river; thence north to Sabine Town, Texas, thence viâ Manny to Mansfield, La., thence crossing Red river at Coushatta Chute Landing to the salines on Saline bayou, and thence viâ Winfield to Harrisonburg on the Washita river, where, after some excursions in the neighborhood, the expedition terminated.

While the presumption as to a general arrangement of the formations in bands, more or less parallel to the Gulf coast, proved to be substantially correct, yet in consequence of local deflections and differences presently to be discussed, the section obtained on the route just recited was less complete than I had hoped. It has, nevertheless, served to develop pretty fully the

main features of the geology of the whole of Louisiana. The unexplored territory will probably, before the end of the season, have been surveyed by Profs. Lockett and Hopkins, of the Louisiana State Seminary at Alexandria, in pursuance of a small provision made for the purpose by the last legislature.

Before proceeding to details it may be well to recall, briefly, the results communicated at the last meeting, of my examination of the formations of Lower Louisiana. I then stated that the southern outline of the main body of the Orange Sand or southern Drift, extends but little south of the limit of the Grand Gulf group, the latest (fresh-water) Tertiary of the Gulf coast; that, nevertheless, in the direction in which the main pebble-stream, coincident with the axis of lowest depression of the Mississippi valley would strike the Gulf, we find a chain of elevations, formed, apparently, by a nucleus of outliers of the Orange Sand materials, surrounded and overlaid by those of the succeeding swamp, lagoon and estuary formation, which from its prominent development at Port Hudson, I have designated as the Port Hudson group; its geological horizon lying between that of the Orange Sand, and the Loess or Bluff formation. I also stated that the deposits of this age extended at least from the Sabine River to Mobile Bay. In fact, I then suspected, and am now confirmed in the opinion, that most if not all the deposits provisionally thrown together under the head of "Coast Pliocene," on my geological map of Mississippi, are the equivalents of the Port Hudson group.

The Port Hudson group.—East of the Mississippi river, the country underlaid by this group of deposits is level or gently undulating, with a gentle slope S.S.E.; the more fertile portions timbered with oak, while on the whole there is probably a predominance of Long-leaved Pine woods, at times degenerating (as in the coast region of Mississippi) into the wet and sterile "Pine meadow" uplands, where the Pine and Cypress grow side by side, greatly damaged by their mutual concessions as to habitat.*

West of the Mississippi, the topographical features are on the whole similar; but instead of being wooded, the surface is almost altogether occupied by prairies, from the Bayou Tèche to the Calcasieu river, and from the marshes of the Gulf coast to an undulating line laid, in a W.S.W. direction, through Ville Plate in St. Landry parish. In correspondence with the portion east of the river, the general slope here appears to be S.S.W., the Port Hudson bluff having its counterpart in those which, abutting upon the bayou Cocodrie below and above Opelousas, have given to very level regions the seemingly inappropriate names of "Côte Gêlée" and "Grand Côteau des Opelousas"; which are descriptive of the appearance when first approached

* Miss. Rep., p. 368.

by water, rather than of the nature of the country itself. As may be supposed under the circumstances, outcrops are exceedingly scarce throughout the prairie region. The wells are shallow, remaining usually within the limits of the upper (silt and loam) strata of the Port Hudson profile; since fetid, undrinkable water is obtained at greater depths, in dark colored clays with fossil wood. Nearer the coast, however, marine beds with oysters, "clams" (*Gnathodon*) and gasteropods are also struck not uncommonly, both near the surface and at greater depths, from the Calcasieu to the Pascagoula river. I have been unable to detect any regular stratigraphical relations between these marine beds and the cypress swamp deposits; they appear to be coördinate and substantially coëval, denoting the coëxistence of littoral cypress swamps, marshes, lagoons and estuaries; just such as would naturally result from a gradual depression of the present coast.

The thickness of this formation near the coast seems to be very considerable. In one of the bored wells on the West Fork of Calcasieu, the materials of the Orange Sand were struck at 160, in the other at 354 feet (see profile below). If such is the thickness of the Port Hudson strata at a distance from any great channel, it cannot be surprising that, in the well bored at New Orleans, in the main channel of the Mississippi valley, it should not have been passed through at 630 feet. Nor is it surprising that, in that great continental depression, marine strata should prevail almost exclusively, when it is considered that at one epoch of the period of slow depression, the swamp formation extended as high as near Memphis on the Mississippi, and Shreveport on Red river.

The banks of Red river in the lake country above Nachitoches (and, according to reliable information, at least as high as Shreveport), as seen at low water, consist of materials scarcely distinguishable from those forming the profile of the sea-face at Côte Blanche.*

There are alternations, every few feet, of stiff red, blue, green or brown clays, with sand or reddish loam; often containing calcareous concretions, sometimes even well preserved fresh-water shells; as well as successive generations of cypress stumps. At the present time, neither the material nor the arrangement of the Red river deposits present any similarity to these strata, any more than do the modern Mississippi deposits to those of Port Hudson; while their thickness, regularity and continuity over large areas, as well as the rarity of stratification lines, distinguish them from the comparatively limited cypress swamp deposits of the present time.

The prairies of South Louisiana, underlaid by the Port Hudson group, embrace, especially in their southern and eastern

* Proceed. Am. Assoc., Chicago meeting, 1868, p. 327.

portion, the most fertile uplands of the state; the region adjoining the Bayou Tèche having, in times past, received and deserved the title of the "Garden of Louisiana"; not inferior in fertility to the bottom lands, and in point of health and comfort much preferable to the latter. From their exposure to the sea-breeze, their summer temperature is much less oppressive and injurious to health, than is the case on the prairies of the North-west; while their bland winter relieves the inconvenience arising from scarcity of wood. Belts of timber, however, border all the streams; and rapidly growing hedges of the Cherokee rose obviate, in a great measure, the necessity for costly wooden fences. Yet the greater portion of this preëminently agricultural region is now merely a range for herds of cattle. West of the Mentau waters, cattle-raising is almost the only occupation of the inhabitants, except near the coast; the white "crawfishy" soil, dotted with clumps of pine, being mostly unfit for cultivation—yet very far from being the dreary marsh, accessible only on stilts or in canoes, and peopled by alligators, which our maps represent as covering most of Calcasieu.

The Orange Sand Formation.—I have heretofore stated that this important series of deposits, seems, west of the Mississippi, to skirt the southern border of the highlands of Arkansas, and to be extensively represented in Louisiana. The latter presumption I have found abundantly verified, since it is as characteristically developed in the latter State, as in the corresponding portion of Mississippi. Outside of the river bottoms and adjoining "hommock" flats, and of the prairies of the Port Hudson group, just described, it appears on all the hill lands, especially on the higher ridges; which are, as usual, capped by rocky knolls of ferruginous sandstone, while slaty fragments of the same strew the slopes. A description of its general features in Louisiana would be, in every respect, a mere repetition of that already given in my Mississippi Report, and other papers since published.* I have, however, to add some facts concerning its general distribution, both horizontally and vertically.

My own observations on this formation have been confined chiefly to the great delta-shaped mass which covers Mississippi, Louisiana, and a portion of the states of Tennessee, Alabama and Arkansas, which bears such obvious relations to the great embayment whose axis is now occupied by the Mississippi river below Cairo, but which was already impressed upon the continent in ante-cretaceous times. Tuomey† and myself,‡

* This Journal, May, 1866; ibid, Nov., 1866, ibid, Jan. 1869.
† Second Report on the Geology of Alabama, p. 146, et al.
‡ Mississippi Report, 1860, p. 27.

however, have early suggested the probable equivalence of these beds with the detrital deposits of the southern Atlantic States, and the universality, in North America at least, of the cause which produced them. No one as yet, has taken up the subject in those States; much as we hear of the Northern Drift, the very existence of the Southern Drift has thus far been studiously ignored in all text-books. Yet it determines the character of the surface, not only of the greater part of five States, above mentioned, and of an important belt along the Atlantic coast, but I have now traced it in its characteristic development, across the Sabine river into Texas, and from scattered observations partly contained in United States and Texas geological reports, partly communicated verbally, I am satisfied that it forms an important feature of the geology of Texas, at least as far south as the Colorado river, and from the escarpments of the Llano Estacado to the Gulf of Mexico. How much farther it may follow the outline of the Gulf—what part, if any, it plays in the Tierra Caliente of Mexico, must hereafter be determined. At all events, its wide distribution alone assigns it a most important place among the formations of the Southwest, and this importance is greatly enhanced by its hypsometrical relations, as I have lately observed them.

I have stated in previous papers, that the depression of the lower Mississippi valley during the "Champlain" epoch cannot have been *less* than 400 feet below its present level—probably, taking into account the depth of water required for the deposition of the materials of the Loess of Louisiana, it must be estimated at fully 450 feet at least. This supposes that the depression commenced from a horizon near the present tide level. But it will be seen by reference to the profile of the Calcasieu bored wells, that in one of them, the Orange Sand had not been passed through at 450 feet below tide level, and near that depth it still contained pebbles requiring for their transportation a considerable velocity of current. The somewhat startling, but inevitable conclusion is, that if the sea level was the same then as now, *the Gulf coast has in late Quaternary times suffered a depression to the extent of at least nine hundred feet* (perhaps more), *and during the Terrace epoch, a contrary motion to the extent of about half that amount.*

The Mississippi river at the present time transports only sand; and were we to construct a general surface level from the northern lake country to the hills of the Gulf border, the fall of water flowing on the surface would still be inadequate to accomplish much more than this. But the nature, both of the surface on which the Orange Sand was deposited, and of

the deposits themselves, prove the action, especially at first, of *violent* currents, capable of transporting pebbles of several pounds weight, hundreds of miles from their original site.* It follows (always provided that the ocean level remained sensibly constant) that the 900 feet change of level, at the mouths of the Mississippi, must have been accompanied by a considerably greater change near its head, one which would more than suffice, at the present time, to establish water communication between the Gulf of Mexico on one hand, and the Gulf of St. Lawrence, as well as (through the ancient channel described, at the Chicago meeting of the Association, by Gen. G. K. Warren) with Hudson's Bay and the Arctic basin on the other; sufficiently great to explain the glaciation of the continent, as well as the succeeding fresh-water flood, whose effects are no less prominent in the southwestern portion of the North American continent, than those of the glaciers are in the northern. And it seems probable that the detailed study of this formation and of its relations to preceding and succeeding deposits, over its wide area of occurrence, is likely to give more important information concerning the geological events immediately preceding our present epoch, than can be gathered from the local accidents of ancient beaches. For while the *presence* of the latter irrefragably proves a *positive*, their *absence* fails to prove a *negative*. Unless absolute continuity is proven, the 30 feet beaches of southern New England cannot be taken as evidence that at Montreal the depression was greater in proportion to the present elevation of its highest beach; or that the (minimum) depression of 450 feet did *not* extend to the Atlantic coast: any more than that highest beach itself can be taken as the mark of maximum depression. Under the rigor of an arctic climate especially, many circumstances might concur to prevent the formation of beach lines, or cause their removal subsequent to deposition. If we assume the glacial epoch to have resulted chiefly or wholly from an uprising of the land, (and perhaps of the sea-bottom also) in northern latitudes, the wide distribution of its effects *there* points to a universality and uniformity of cause, quite analogous to that which seems to obtain in reference to the southern or Stratified Drift, from the Susquehanna to the Colorado of Texas; and (as regards the maximum of reported change of level) from the Gulf of Mexico to the Arctic coast. It is permissible to infer, that these great events were not confined to the Atlantic slope; and that the auriferous gravel beds of California are, in all probability, the strict equivalents of the "Orange Sand" of Mississippi; while the period of time required to cover the pebble

* See Mississippi Rep., 1860, pp. 13, 26, et al.

streams of Louisiana with many hundred feet of swamp and marsh deposits, may well embrace the successive lava streams now overlying the gravel of California.

The Grand Gulf group.—The materials of this formation characterize, more or less, the portion of Louisiana lying northward of the prairies of the Port Hudson era, up to a line laid in a W.S.W. direction, through Cloutierville on Red river; where, at the foot of elevated ridges consisting of Grand Gulf sandstones and claystones, the limestones and marls of the Vicksburg Eocene Tertiary begin to prevail.

The features of the Grand Gulf group in Louisiana are almost absolutely identical with those prevailing in Mississippi.* In the more southerly portion of its area of occurrence, its materials are hard, intractable blue, green or gray, massy clays or clayey sands, appearing chiefly in the beds of streams, and thickly overlaid by the deposits of the Orange Sand; to whose lower portion it has communicated its clayey character, resulting in the formation of excellent potter's clay. On the higher ridges, the ferruginous sandstone of the Orange Sand prevails largely and characteristically.

Farther northward, however, as in Mississippi, gray or white, mostly soft and somewhat clayey, sandstones, alternating with siliceous claystones of various degrees of induration, and gray, sometimes lignitic, but mostly massy clays, themselves constitute the ridges, forming rather barren soils, on which the long-leaved pine and coarse grasses alone can find sufficient nutriment. Yet even here, wherever a particularly prominent ridge or knoll is seen, it is sure to consist of an outlier of Orange Sand, perched on a plateau of Grand Gulf rock and capped by a ledge of ferruginous sandstone.

As regards the general arrangement of the strata, they doubtless dip slightly to the southward; though it is difficult to observe this in any one outcrop. Probably the dip is but slightly greater than that of the average surface of the country, for I have found nothing to indicate that the sand and claystones which form the ridges on the northern border of the formation, underlie the clays found on the southern edge. My impression is that the former have either never been formed in the latter region, or else have been subsequently removed.

My hopes of finding, in the reported limestone deposits on the territory of this group, a clue to its position in the Tertiary series,† have been disappointed. The limestone of St. Landry proves to be a Cretaceous outlier: while that occurring near Harrisonburg, capping the highest hilltops of Sicily Island,

* Mississippi Report, 1860, p. 147; this Journal, Jan, 1867, p. 39.
† This Journal, Jan., 1869, p. 9.

consists of the gnarled and knotted concretions characterizing the Bluff formation ("Loess-puppets"), which contain the Helices usual in that group. Faint and usually irrecognizable impressions of leaves sometimes occur, as is the case in Mississippi; but in the present condition of phyto-palæontology, little can be hoped for from that slender source. In its stratigraphical, lithological and structural characters, it differs widely from all the other tertiary deposits of the Southwest; its slight dip alone proving it to be of comparatively modern origin. Whatever may be the precise epoch of its formation, that event could not have been a local one, due only to a littoral shallowing of the Gulf. The regularity, as well as the uniformity of composition of the strata, from the Escambia river to the Colorado of Texas, alone seems to forbid its being considered, like the Port Hudson deposits, as the representative of a period of swamp and estuarian formations on the border of a marine basin. I have heretofore suggested,* that nothing short of a temporary cutting off of the Mexican gulf from the Atlantic seems capable of accounting for the existence of the Grand Gulf strata; and this impression has been nowise weakened by a more extended acquaintance with this remarkable formation.

While the territory of the Grand Gulf group is on the whole perhaps the least fertile portion of Louisiana. (as is likewise the case in Mississippi), there are some notable exceptions to this rule, in regions where a calcareous clay stratum† comes so near the surface as to contribute to the formation of the soil on the hillsides and in the bottoms. Such is the case on the upper bayou Anacoco (in the "Anacoco prairie" region) as well as in the southern portion of Sicily Island, near Harrisonburg on the Washita. Whether the Avoyelles prairie belongs to the same category, I have been unable to ascertain; but from its position it seems likely that such is the case.

This white clay marl, the building stones occurring in the northern portion of the formation, the potter's clays above referred to, and a pure white and exceedingly refractory, semi-indurate white pipe-clay, occurring near the edge of the Vicksburg rocks in Catahoula parish, constitute the practically useful materials of this group in Louisiana; where on the whole, it yields much fewer waters impregnated with noxious salts, than is the case in Mississippi.‡

The Vicksburg group.—The territory underlaid by the rocks

* This Jour.. Jan., 1867, p. 41.

† Probably the same as that which appears on Pearl river, in Marion Co., Miss., at "Barnes' White Bluff," and has been used as a fertilizer (Mississippi Report, 1860, p. 179).

‡ Ibid, p. 187, et al.

of this division of the Eocene Tertiary, forms a band about thirty miles wide, crossing the state in a W.S.W. direction, north of the Grand Gulf group.

The features of the Vicksburg group, where it is crossed by the Washita, seem to agree closely with those given in my general section (p. 140 of the Mississippi Report of 1860). According to the observations of my companion, Dr. Walker (who determined the line between this and the Grand Gulf group, on the Washita), lumps of Orbitoides limestone at the foot of the Grand Gulf sandstone ridges, are the first evidence of the change of formation. Thence northward, lignito-gypseous clays are reported for some distance, while about six miles below Columbia, according to information from residents, there are limestone hills with small shell prairies and marl beds.

Northward of Columbia, calcareous strata corresponding to the Jackson group do not seem to occur on the Washita until we reach "about fifty miles (by water) south of Monroe," the locality from which Dr. Harlan obtained the vertebræ of Zeuglodon described by him in 1832.* Thus far, the section of the marine Tertiary on the Washita corresponds very well to that on Yazoo and Pearl rivers, in Mississippi; only the intervening lignitic stratum, which forms the base of the Vicksburg bluff, is more extensively developed on the first mentioned stream.

On the Sabine river, too, the upper portion of the profile is pretty correctly reproduced. At the base of the Grand Gulf rocks we find, on the bayou Taureau, a seam of shell limestone with Vicksburg fossils. We then pass over lignito-gypseous strata to Sabine Town, Texas, where we see about seventy feet of these, overlying ledges of blue fossiliferous limestone alternating every two or three feet with what would be greensand marl like that of Vicksburg, had not the lime of the numerous shells of which it contains casts, been removed by subsequent dissolution. So far as I have seen, the usual leading fossils of Vicksburg are wanting here; while the greater sandiness of the materials, as well as the prevalence of shallow-sea bivalves, indicates their deposition in shallower water. As we proceed northward from Sabine Town, lignitic clays and lignite alone separate, and sometimes altogether replace, the limestone ledges, which themselves become poorer in fossils, as we approach the northern edge of the formation.

Beyond, we again enter upon lignitic territory, which thenceforth continues with unbroken uniformity, so far as the Tertiary is concerned, to the Arkansas line.

* Trans. Am. Phil. Soc., vol. iv, N. S.

From my own observations farther east, as well as from information obtained from others, it seems that there is a gradual increase of the lignitic clay facies in the Vicksburg strata, as we advance westward from the Washita. The Casatche Hills below Natchitoches are described as consisting of alternating limestone and marl strata, capped by Orange Sand knolls; while the "Grande Ecore" on Red river, a few miles above Natchitoches, exhibits only dark laminated clay and sand. In the flat region between Dugdemona and Red rivers, where I recrossed the Vicksburg territory, there is but little chance for observation; but about the middle of the belt, on the heads of Bear creek, semi-indurate marls with *Orbitoides*, *Pecten Poulsoni* and *Ostrea Vicksburgensis*, are abundant; as well as farther east, the nodular Orbitoides limestone, at the base of the Grand Gulf rocks.

The Mansfield group.—In Mississippi the stages of the marine Tertiary are separated by lignitic clay strata; in Alabama, on the contrary, they are directly superimposed upon each other.* The lignitic bands gradually increase in thickness as we advance westward, but the territory underlaid by them in Mississippi is generally too limited, and the development of the strata too slight, to necessitate their designation by a special name. At Vicksburg, nevertheless, the thickness of the lignitiferous stratum intervening between the Vicksburg and Jackson groups, is not less than 35 to 40 feet, and it underlies a district several miles in width, on the Yazoo bluff.

In western Louisiana, as already stated, none but lignitiferous strata of Tertiary age, occur north of the Vicksburg group, as far north as Shreveport, and so far as I have been able to ascertain, up to the Arkansas line. In fact, the only locality in Louisiana known to me as distinctly of Jackson age, is that already mentioned as the source of Zeuglodon bones, described by Dr. Harlan, about half way between Columbia and Monroe, on the Washita. Nor does the main body of the marine Tertiary seem to extend any farther west in Arkansas, the outcrops mentioned by Dr. Owen being chiefly on Washita and Sabine rivers, in about the same longitude; to the westward of which excepting an outlier of Tertiary limestone in Clark county, the Tertiary epoch seems to be, in both states, represented by lignitiferous, fresh or brackish-water deposits. Nevertheless, the characteristic marine fossils of the Jackson group, according to Buckley† occur abundantly in (southeastern ?) Texas.

Very probably, the equivalents *in time* of all the marine groups exist in the lignitic Tertiary of Arkansas, Louisiana

* This Journal, Jan., 1867, p. 30.

† Prelim. Report on the Texas Geol. Survey, 1866, p. 44.

and Mississippi, their change of character denoting a change in the depth (and consequently in the character) of the waters in which they were deposited. It will be extremely difficult to define the portions corresponding to each of the various marine epochs ; meanwhile, I propose to designate as the *Mansfield group*, that portion which, from its geographical position and general uniformity of materials, seems to be the equivalent of the lower portion of the Vicksburg bluff. It is very characteristically developed near Mansfield, La., and there presents a feature foreign to the other lignitic groups I have investigated, viz: a ledge, $\frac{3}{4}$ to 2 feet thick, of an impure, laminated limestone with numerous, but mostly fragmentary, impressions of lignitized stems and leaves. A narrow ($\frac{1}{4}$ to $\frac{1}{2}$ in. wide) band of this rock seems to extend from Mansfield as far as Shreveport, appearing mostly a few feet below the hilltops. Bluish-gray, clayey sands and mouse-colored laminated clays are the predominant materials, with which lignite beds are frequently associated ; and near these, well preserved impressions of leaves are not uncommonly found. The surface of the territory occupied by this group is undulating, sometimes (on the rivers) hilly ; and as usual, the higher ridges are everywhere capped by the Orange Sand, whose ferruginous solutions have frequently metamorphosed the subjacent Tertiary material into ferruginous shale or sandstone ; at the same time forming above the line of contact large deposits of concretionary Brown iron ore,* containing from 40 to 60 per cent of hydrous peroxyd, which will doubtless in time become of considerable practical importance.

Numerous and extensive lignite beds exist in northern Louisiana, the economical importance of which is already beginning to be appreciated.

The limestones of the Vicksburg group at many points yield excellent lime, while the more impure varieties possess in the large amount of glauconite they contain, special advantages for agricultural purposes. Good marls of various kinds also abound. These calcareous materials are the more important in an agricultural point of view, because the soils of the territory, both of the Vicksburg and Mansfield groups have in general a foundation of pretty stiff red clay, derived from the lignitic clays, upon which stimulation produces a great and lasting effect. This red subsoil may almost be considered characteristic of the uplands of northern Louisiana ; which are very far from being "Pine Woods," in the sense in which the expression is understood east of the Mississippi ; especially where the Vicksburg rocks underlie.

* Mississippi Report, 1860, pp. 23, 24.

The Cretaceous outliers, presently to be mentioned, furnish limestone containing only 1 to 1·5 per cent of impurities, and are sometimes chemically pure carbonate.

The Salines of North Louisiana.—One of the most striking features of North Louisiana is the occurrence of salt springs and licks, usually accompanied by outcrops of limestone, which appear sporadically, but usually near the water courses, mainly near the head of Lake Bisteneau and on the waters of Saline bayou, in the parishes of Bossier, Bienville and Winn.

Brines of considerable strength and purity are obtained in these licks by sinking shallow wells or pits, usually to the depth of 14 to 20 feet. Sometimes brine is obtained in sand, without striking any rock ; most frequently, a bed of limestone is encountered, sometimes compact, more frequently coarsely and incoherently crystalline, consisting of more or less horizontal bands or aggregates of white, yellow or black calcareous spar. Beneath this rock, of a few feet thickness, a bed of white or gray granular gypsum of 12 to 20 inches thickness, frequently appears, and beneath this the brine is reached, in a sandy layer.

At several points deep borings have been made in these licks, from 200 to as many as 1,100 feet, whereby an increased and, in some cases, an artesian supply of brine has been obtained. The precise records of these borings have been lost ; but in one case at least the pile of borings, in others tradition, testifies that calcareous or gypseous materials were met with all the way. This fact coupled with the lithological character of the latter (which is foreign to all the Tertiary groups known to me), and a "find" of several individuals of *Exogyra costata* and *Gryphœa Pitcheri* in the rubbish of one pit, suggests that we have here, not local Tertiary basins, but rather the peaks of a Cretaceous ridge, projecting through the lignitic Tertiary ; whose lithological characters agree closely with those described by Dr. Owen as characterizing a portion of the Cretaceous of Arkansas, and equally corresponding to those observed on the upper Red River, near Fort Washita, by Dr. G. G. Shumard.*

The highly crystalline, non-fossiliferous, horizontally banded limestone which characterizes most of these saline outliers, reappears independently farther south, in the shape of limestone ridges elevated perhaps a hundred feet above the drainage of the country ; as near Winfield, and on Saline Bayou below Drake's Salt Works.

It will be observed that the general trend of the body of these outliers is about S.E. and N.W. A continuation of this line strikes the main body of the Cretaceous of Arkansas, in Hempstead county, on the one hand ; on the other, a body of

* Marcy's Exploration of Red river, p. 195.

limestone of precisely similar character, near Chicotville in St. Landry parish, La., on the territory of the Grand Gulf group, which in the absence of other evidence, I had previously referred to the latter (see above). Its absolute lithological identity with the limestones of Northern Louisiana, as well as the incongruity with all other materials heretofore observed in the Grand Gulf or other Tertiary deposits, leave little room for doubt that here, within 70 miles of the Gulf coast, we have another Cretaceous summit rising out of the Tertiary. And if we follow still farther the general line of trend, southeastward, we light upon the group of Five Islands, and notably the rock-salt deposit of Petite Anse.

It is perhaps too early to discuss the question, whether the latter coincidence is accidental, or whether this ancient Cretaceous ridge thus forming the "backbone" of Louisiana, has caused, not only the shallowing of the older Eocene sea into marshes and lagoons, but also the eastward deflection of the lower Mississippi, and explains the simultaneous existence of salt both in North and South Louisiana. If rock-salt, however, should be found to form any part of the Cretaceous rocks of the southwest, a Cretaceous outlier at Petite Anse would be scarcely more strange than the limestone outcrop near Chicotville. The presumption is still farther strengthened by the phenomena observed in the wells bored near the West Fork of Calcasieu river, about twelve miles west of Lake Charles in Calcasieu parish.

The Artesian wells of Calcasieu.—These are located on two small islands in the (fresh-water) marsh which forms the head of bayou Choupique, a small tributary of the main Calcasieu river. It was long known that on one of these islands there existed "tar springs" which had formed an asphaltum pavement on a portion of the surface, and continually evolved combustible gas; and not long after the close of the war, boring operations were commenced there by the "Louisiana Petroleum and Coal Oil Co.," whose auger had, at the time of my visit, reached a depth of 1,230 feet.

Another bore has been commenced on an island about 700 yards to the westward; the work, now carried on by Dr. Kirkman of Lake Charles, has reached a depth of 450 feet. The following is a comparative profile of both wells.

The data for the following profile are derived, for position and thickness, from the statements of the well-borers; the materials are given from samples of the borings picked from the pile by them in my presence, and I have every reason to think that the facts are faithfully represented.

As regards the interpretation of the formations penetrated,

Profile of Artesian Wells, west fork of Calcasieu river.

Kirkman's Well.			Louisiana Oil Co.'s Well.			Formations.
Depth.	Thickness.	Materials.	Depth.	Thickness.	Materials.	
Ft.	Ft.		Ft.	Ft.		
		Blue and yellow clay, with some sand strata.	160	160	Blue clay, sometimes with layers of sand soaked with petroleum.	Port Hudson Group.
	354		333	173	Loose sand and gravel, 138 to 153 ft. very pebbly; 153 to 173 ft. finer material.	Orange Sand Group.
			343	10	Gray laminated clay ("soapstone").	Vicksburg Group.
	96	Sand with clay laminæ, 36 ft. Sand and gravel, 56 ft.	383	40	Blue, sandy, nodular limestone, with marine shells. Petroleum and gas.	
450	----	Sandy pipeclay, 4 ft.	443	60	Soft, white, crystalline, crumbling limestone; tube driven through.	Cretaceous Formation.
			543	100	Pure crystalline sulphur.	
			690	147	Sulphur and gypsum, alternating. About ⅓ sulphur. 5 ft. Sulphur bed at 650 ft. 10–15 " " 680 "	
				540	Pure gypsum. Dense, granular, and coarsely crystalline, grayish or white.	

there can of course be no doubt as to the identity of the Port Hudson and Orange Sand groups. It is interesting to note, that here as elsewhere the Orange Sand rests on a deeply denuded surface, and has itself suffered subsequent denudation; as is evidenced by its relative levels in the two bores. The pebbles are of the usual character; chiefly chert and siliceous sandstones, still showing impressions of palæozoic fossils; the largest observed weigh about five ounces.

While Kirkman's well has chanced upon a valley of denudation, the Company's well has struck a ridge whose summit has resisted denudation by the aid of a cap of hard clay shale, in which, besides, there was a layer of sandstone. As soon as this was penetrated there was a violent rush of combustible gas, and water mixed with petroleum. The amount of the latter however, never exceeded a few barrels a day, even when the pump was used; and great difficulty was experienced in pene-

trating the stratum of loosely piled, disjointed, rounded lumps of blue limestone, which kept tumbling in from the sides. This is evidently the oil-bearing stratum, and (reports to the contrary notwithstanding) I am satisfied that no fresh supply of oil was found after reaching the underlying white limestone.

The rare shells contained in the blue rock are too ill-preserved to allow of specific determinations; but their very state of preservation, no less than the peculiar lithological character of the rock, suggests at once the correspondence to the base of the Sabine Town bluff; which is, moreover, corroborated by the comparative chemical and microscopic analysis. The lignitic nature of the intervening beds, as well as the occurrence of asphalt in the Vicksburg limestone of Mississippi, are suggestive with reference to the oil-bearing feature. The overlying clay stratum likewise coincides.

As to the underlying white limestone, it is a material utterly foreign to any of the Tertiary groups of the Southwest, while coinciding precisely with some of the limestone of the saliferous cretaceous outliers of North Louisiana; here again, chemical as well as microscopic characters coincide as strikingly as they differ from those of the blue oil-bearing rock.

For the immense *sulphur bed* underlying, we have no direct precedent, unless it be the occurrence of a sulphur-bearing earth in the gypsum formation on Delaware creek, on the southern border of the Llano Estacado, observed by Capt. Pope.* But the interstratification of sulphur and gypsum in the lower bed proves the closeness of their mutual relation, while the enormous thickness of the underlying gypsum bed recalls at once the great gypsum formation of the upper Red river, and the Llano Estacado; faintly represented by the gypsum beds of North Louisiana, and Arkansas.

The age of the great gypsum formation has been the subject of much discussion. It has always seemed to me that the great extent of the area over which the Cretaceous beds and underlying gypsum are known to be coëxtensive, went far to prove that they belonged substantially to the same epoch. Whatever weight may attach to this argument is greatly enhanced when we find the crystalline limestone and underlying gypsum not only reappearing in northern Louisiana, but actually accompanying each other beneath the waters of the Gulf of Mexico. Whether the volcanic agencies which even now so frequently disturb that great basin, have been instrumental in reducing the sulphur, distilling the petroleum, and crystallizing the rock salt of southern Louisiana, may be more profitably discussed

* Report of an exploration of a route for the Pacific railroad, near 32d parallel; Geology, by W. P. Blake, p. 38.

when more extensive excavations shall have given us an opportunity of closer inspection of the facts. As regards the sulphur bed, it seems strange that no such opportunity is as yet foreshadowed in the near future; although in my view, its practical importance can hardly be over-estimated. Its development requires, it is true, large capital and the best of engineering resources, in view of the depth, and peculiar difficulties of drainage and ventilation. But who that knows the part sulphuric acid plays in modern civilization, the monopoly enjoyed by Sicilian sulphur, the burdens naturally and artificially imposed upon its production in that island, and the inferiority of the acid prepared from pyrites, can fail to appreciate the intrinsic importance of a bed of pure sulphur some 135 feet thick, lying at a depth less than half of that at which some coal mines are profitably worked in Pennsylvania; and within ten miles of ocean navigation! The very gangue of the mineral—gypsum—is of sufficient value in agriculture and the arts, to bear shipment for thousands of miles, within the country. Nor indeed, is it likely that beds *of such magnitude* should be confined to a limited area, and not be accessible at more advantageous locations.

As regards the prospect of obtaining petroleum in paying quantities, the inconsiderable thickness of the Vicksburg rocks, and the obvious fact that they are traversed by valleys of denudation, are very unfavorable omens.

The water now flows from the Company's well at the rate of 65 gallons per minute; rises 12 feet above the surface. It is a *saturated solution* of sulphuretted hydrogen, with a little gypsum and common salt. This stream flows chiefly from the surface of the sulphur bed. Boring operations at this well have been suspended, and a company is now being formed with a special view to mining the sulphur.

ON THE NATURE OF THE MOVEMENTS INVOLVED IN THE CHANGES OF LEVEL OF SHORE LINES.

BY N. S. SHALER.

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CHANGES OF LEVEL OF SHORE LINES.

Accurate observations on the changes of position of the earth's surface at different points have been thus far limited to the lines where the sea and land meet.

Nowhere away from shores are there means by which alterations of elevations can be detected by easily made comparisons. The habits of men cause the slightest changes of the sea level to be immediately noticed, so that all modifications of the shore line meet with attention, while alterations of far greater extent, at points remote from the sea, would pass unregarded. Nor can we expect, in the present imperfect method of determining the contour of inland irregularities of surface, much more accurate data from which to decide whether any region maintains over its whole surface the same relative level during considerable periods of time. Even the most trustworthy methods of determining relative levels of points remote from shores are so liable to accidental errors, that it is doubtful whether unquestionable observations are to be attained. Being thus limited to the shore line for our accurate data concerning elevations and depressions of the land, it becomes a matter of first importance to determine what are the valid deductions which can be made from the observations we may obtain there. We should ascertain how far the upward and downward movements indicated by the unerring water level can be attributed to the general area in which the shore lies, before the true value of these movements as indices of geological changes can be determined. At first sight it would seem an unnecessary labor to examine a question which appears so perfectly clear in all its bearings; it certainly looks unlikely that elevation or subsidence of the shore could indicate anything but the general rising or sinking of the land

area to which it belongs, yet, on examination, it will be easily seen that these indications are far from being as decisive as would at first be supposed.

Before entering upon the question of the cause of those movements of the solid surface of the earth, which result in the changes of level at the shore line, it is necessary to attend to some of the more general facts deducible from the phenomena. The most important result of the observations which have been made, is that the movements are in no case local, that is, no portion of shore of a mile, or even at few tens of miles in extent, is to be found in rapid process of change of level adjacent to immovable lines of shore; on the contrary, the movements, while they may vary in force, and fade away in any direction, do so with a regularity which shows that the force is very widespread and uniform in its action. Another important feature is, that an upward movement on one portion of a coast may gradually diminish and pass into a subsidence on the same coast line. Looking still further, we perceive some very peculiar features in the distribution of the changes of level which are still going forward, or which have taken place since the close of the glacial period. All those regions which exhibit distinct evidence of the former existence of the ice envelope, show also unquestionable proofs of elevatory action, since the passing away of the glacial condition. A still more intimate connection between glaciation and change of level is exhibited in the increase in the elevation of ancient sea margins, as we go from the regions where the ice had its southern limits, towards those points where there is any evidence to convince us that it attained the greatest thickness. Although our information wants the precision which can make accurate comparison possible, there is no doubt that the increase in thickness of ice was attended by something like a proportionate augmentation in the submergence of the land. The brief period during which these changes of level have been subjected to careful investigation, has shown no case where the same point has been alternately under the influence of elevatory and depressive actions, but from the study of the record of such movements since the glacial period, we have abundant reason to believe that such alternations are very frequent, and that it is the exception, rather than the rule, that the same point on the shore has continued under the influence of either elevatory or depressing forces during the whole of the present period.

Upward and downward movements, with long intervals of rest,

during which beaches were formed, and precipices excavated by centuries of incessant wave action, are shown along all the coasts lying within the glacial zone.

The great length of the shores on which we find evidence of the rising or sinking of the land, and the prevailing uniformity of movement over great areas, and in great lengths of time, require us to suppose that a great thickness of the earth's crust partakes of the motion, and that the forces producing the change are constantly in action, and not of that instable and transitory character which belongs to ordinary volcanic agencies. At the same time, we have the perplexing facts of alternation of elevation and subsidence to reconcile with this uniformity in other regards, and no hypothesis which fails to account for this extreme variability in the character of the movement with the equability of the action over wide areas, will be entitled to consideration.

Our evidence shows us sea lines of thousands of miles in length, which have, during the present period, been undergoing a tolerably uniform upward movement. Are we to suppose that the extension of this movement on lines at right angles to the shore has been as great, or are we rather to suppose that the action of elevation acted along one line, and that this line, for some reason or other, has coincided with the shore? This question leads us to search for the nature of the cause of these shore oscillations of level.

If we assume that the great folds of the earth's crust, termed continents, are the result of the accommodation of the outer envelope to a diminished interior, then it follows that in such movement the sea furrows would be steadily lowered, and the continental folds correspondingly elevated above the shore line as contraction went on. The author has elsewhere briefly stated some reasons for believing that through the deposition of sedimentary matter, and the consequent rising in the isogeotherms in the strata beneath, the ocean floors would always bend downward, and the land areas bend upward, as the shrinking of the interior of the earth went on. Be this as it may; the result of the sinking of the ocean bottom and the elevation of the land, would necessarily be the movement of the segment of the crust from the centre of the continents to the centre of the sea, with the axis of rotation or fulcrum point, near the shore line. If the continents and sea basins owe their origin to wrinkling of the crust, this conclusion seems to be necessary. Admitting such a rotation about a line near the shore, then it follows that one of three conditions may prevail. It is possible that the point of rotation may be precisely at

the shore, to the seaward of the shore, or some distance from the water on the surface of the land. It will be easily seen from inspecting the accompanying diagram, (Fig. 1,) that in the former case, very extensive actions of subsidence and elevation might take place without affecting the position of the shore line in the least, unless in the changes of level the holding capacity of the sea basin was greatly modified; any such effect would necessarily be very slight, as it would be equalized by the waters of all the oceans. In the third condition (Fig. 1), that where the pivot point was to the landward of the shore, there could be no other result than the apparent sinking of the shore, and the advance of the sea line towards the land.[1] The remaining con-

[1] In the diagrams 1 and 2, similar letters denote corresponding points.

In figures 1 and 2, the straight lines A, B, A′, B′ are diagrammatic expressions for sections extending across the shore. For convenience of delineation, the action of the movement of the small segments of the crust represented is supposed to be like that of a rigid bar.

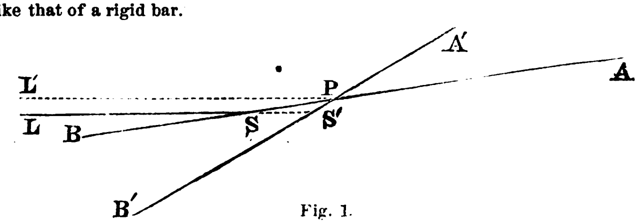

Fig. 1.

In Fig. 1, the pivot point, P, is to the landward of the shore, S, the line A, B, indicating the surface of the continent near the coast. Let the depression of the sea floor and the elevation of the land go on until the continental surface is in the position indicated by the lines A′, B′, and the shore will be removed to the point S′, and the sea gains. S, L indicates the sea level. If we suppose, however, that the dotted line P, L′, denotes the sea level, then the pivot point will fall just at the shore line, and all the changes in the position of the line A, B, will not affect the position of the water lines.

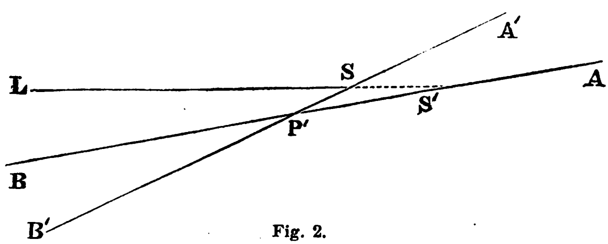

Fig. 2.

In Fig. 2, the pivot point is the seaward of the shore line A, B, indicating the original position of the continental surface, and A′, B′, the position of the change.

dition (Fig. 2) would be always accompanied by the apparent elevation of the shore, and the gain of the dry land on the sea. Thus we see that the relative position of the pivotal point to the shore line may produce such apparently contradictory actions as rise and fall of the land. It is evident that the precise position of the pivotal point must be very much a matter of accident. Trifling causes may effect its removal to such a distance, that in a comparatively brief time, the same region of shore may be just upon the fulcrum point, or to the seaward or landward of it, and thus experience the three conditions of permanence, subsidence or elevation.

The line of no movement, or axis of rotation, would, on account of the great rigidity of the crust, tend to have a rectilinear direction, or at least far fewer curves than usual on shore lines; assuming that it is for limited regions in effect a straight line which may have a considerable angle to the general trend of coast, we perceive at once that the resulting movements at different points may be very varied.

All one extremity of a coast may have a movement in one direction, the middle portion may be stationary, and the other extremity be affected by a movement in the opposite direction. Where a shore is deeply indented, the extremity of a cape or promontory may be to the seaward of the axis of rotation, and be on that account sinking, while the main land may be within the axis of movement, and exhibit evidences of elevation. Inspection of the diagrams will show how far the relation of the shore line to the axis of rotation can complicate the evidences of movement of different points.

It must not be supposed that this hypothesis requires that the sections of the crust from the centre of the sea to the centre of the con-

Inspection will show that in this diagram the change has caused the shore to move seaward, and the land gains.

Fig. 3 represents a shore line with an axis of rotation, A, B, cutting it in such a

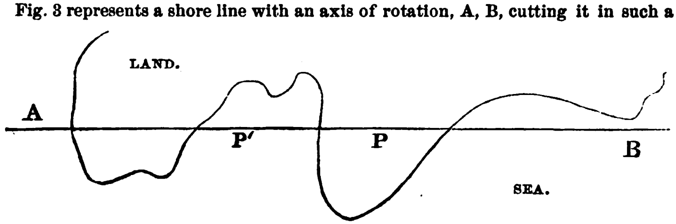

Fig. 3.

manner that the points P and P′ may be taken for the pivot points of the diagrams 1 and 2, respectively. All that portion of the shore line to the right of the straight line would be sinking; all to the left rising.

tinents, move as a rigid mass, for on such a supposition we would be obliged to suppose that a movement of a few inches at the shore, near the pivot point, must indicate a movement to the extent of thousands of feet in the central regions of the oceans or continents. It is likely that, as the earth loses heat and contracts, the sea floors subside, and the land areas rise at something like the same rate over their whole surfaces. The general form of both continents and ocean bottoms makes this supposition seem very probable.

Without considering the proof of the validity of this hypothesis, which would be beyond the author's purpose at present, it may be noticed that there are many phenomena better explicable on this view than by any other hypothesis which has been presented. First among these are the alternations of elevation and subsidence, so frequently observable in shore deposits of the present and former geological period. There is no way by which these actions are so easily explicable as on the supposition of a change in the position of the pivot point of such a movement of the earth's crust, as we have described. The hypothesis demands the supposition of a constantly subsiding ocean floor, or at least the absence of any general elevation of the central regions of any ocean. This view is in accordance with geological evidences. At all times in the earth's history we have evidence of continued subsidence of ocean floors, taking place by a movement so gradual that the deposition kept pace with the sinking, so that thousands of feet of strata were laid down in an ocean which remained always shallow.

If we could accept the theory so ably presented by Mr. James Crool, which assigns as the cause of the subsidence of the shores within the glacial limits, the accumulation of ice about the pole, and the consequent change in the portion of the earth's centre of gravity, then we might easily refer all the upward movements indicated by raised beaches to such action, and remove them from the purview of the hypothesis we have just discussed. But as much doubt exists as to the validity of Mr. Crool's hypothesis, it may not be out of place to notice some facts which seem to militate against it. If his view were correct, we should expect to find in regions of the same latitude something like an equal amount of depression indicated by the raised beaches, and other marks of littoral action. This does not seem to be the case. The beach lines of the glacial period are much higher on the North American than the European coast. At Brooklyn, in about the latitude of Naples, there are evidences of the sea at one hundred feet above the water level. On Lake Champlain, on the

parallel of Cape Finesterre, at a height of about five hundred feet, we have well defined littoral phenomena. The comparison might be carried still farther with a prevailing result, that the North American continent received a deeper submergence than the European shore evinces. A comparison of regions near at hand affords us similarly strong grounds for questioning the probability of equal submergence of regions of the same latitude. Nowhere along the coast of Maine have we shore lines more then two hundred feet above the present level of the sea. Within the same parallels in Vermont the subsidence was quite double that depth.

It is true that all such evidence is of a negative character, and it may be argued that if we had precise knowledge of the highest point to which the sea attained in different regions, it might, with allowance for recent alterations of level, show an equality of submergence of all shores under the same parallel. But until such conjectures are proven, we cannot accept the comparative elevation of ancient shore lines in different latitudes, as evidence of Mr. Crool's hypothesis. A further objection is to be found in the irregularities in the movements in high Northern regions. If the formation of a large ice cap about the pole was the cause of the subsidence of Northern regions, then we would expect something like uniformity in the action of the sinking; but in Scandinavia and elsewhere, we have evidence of repeated alternations of elevation and subsidence, which could be explained in no other manner than by the unsatisfactory conjecture, that for some unknown reason the ice cap was subject to sudden alternations of level. The changes of level now going on on Northern shores, seem to be but a continuation of the modifications which have left their traces in the ancient littoral phenomena of those regions, and yet all these movements are not elevatory; part of the shore of Scandinavia is indeed rising, but another portion is subsiding, and a large part of the west shore of Greenland is undoubtedly undergoing a gradual depression.

If any value whatever is to be given to the theory of Mr. Crool, there would still remain very important coöperative actions, which would have to be understood before the whole of the phenomena could be explained. On consideration, it will appear probable that important effects on the position of the land surfaces would be exercised by the rise in the isogeothermals from the non-conducting power of the ice cap of the glacial period.

The accumulation of seven thousand feet of ice upon any one portion of the earth's crust must, it would seem from its great non-conductive power, exercise as great an effect upon the temperature

of the rocks below, as would the addition of an equal thickness of ordinary sedimentary nature; that is to say, the lines of equal heat would move outwards from the centre to the extent of three thousand feet. This increased temperature of the deeper portions of the earth's outer crust, would necessarily be attended by an expansion of the materials composing such crust. If the substance thus affected by heat, had the coefficient of expansion belonging to granite, and the diameter of the region affected be supposed to be one thousand miles, then the amount of this expansion would be about thirty-seven hundred feet. Now inasmuch as the uppermost part of the crust, i. e. the ice sheet, would not partake of this increase of temperature, and would not have its bulk affected by the movement of the isogeothermals, we would have one portion of the crust affected by a movement, while the remainder was at rest. In this case there can be no doubt but there would exist a great tendency of the area thus affected to bend downward.[1] If the condition of the deeper portions of the earth was such as to admit of the outer crust obeying this tendency to bend downward, as given by the expansion of the beds below, arising from the accumulation of glacial material, there would seem to be no difficulty in the way of our finding an explanation of most of the phenomena of subsidence connected with glacial action. It is not to be denied that all the evidence goes to show that we can no longer retain that theory of the earth's structure which supposes a hardened outer crust resting upon a fluid or viscid nucleus. But there are many reasons for believing that though the deeper regions of the earth are as rigid as the superficial portions, there exists, nevertheless, a zone not far from the surface where a considerable portion of matter still remains in a sufficiently softened state to admit of considerable movement in the hardened crust which rests upon it. But without attempting to discuss here the question of the nature of the means by which movements of the crust take place, we may safely assume that the conditions do now, and always have admitted a considerable up and down motion of the crust of the earth. How far the glacial sheet may have served to bring about these changes of level, or in what way the ice has operated, are questions which cannot well be discussed until our knowledge of the facts connected with glaciation

[1] Under these circumstances, the behavior of the coast would be exactly illustrated by the action of a bar composed of two metals having different coefficients of expansion soldered together (as in the thermometer of Bréguet). On the application of heat the bar will be bent, the arc *pointing* in the direction of that portion of the bar having the greatest coefficient of expansion.

and submergence is more complete. It does not seem to be too hazardous, however, to venture the assertion, that the extent of glacial submersion will be generally found to be proportionate to the depth to which the glacial accumulation attained. Not that any fixed ratio will be discoverable, but that where the glacial sheet was great, the subsequent subsidence was also considerable, and that where the glacial mass attained to no great depth, the subsidence was also slight. If this correspondence should be sufficiently verified, we shall be driven to suppose that the phenomena of glaciation and subsidence stand to each other in the relation of cause and effect, and that the ice sheet operates not in a general way by the change in the centre of attraction, rising from the circumpolar accumulation, but directly, through the means of forces brought into action by, and proportionate to, the thickness of the glacial sheet. It is difficult to imagine any other way in which the ice could so operate except by the change in the position of the isogeothermal lines.

It should be remarked, however, that the view of the agency of ice in producing subsidence, does not seem to the author by any means conclusive; but only sufficiently probable to warrant its suggestion to those students whose special knowledge of thermodynamics better fits them for the discussion of such questions.

CATALOGUE

OF

Official Reports upon Geological Surveys

OF THE

UNITED STATES AND BRITISH PROVINCES.

[From the American Journ. of Science and Arts, Vol. XLIII, Jan., 1867.]

A CATALOGUE

OF

OFFICIAL REPORTS UPON GEOLOGICAL SURVEYS

OF THE

UNITED STATES AND BRITISH PROVINCES.

Part I.

The dates express the year of publication

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[From the American Journ. of Science and Arts, Vol. XLIII, May, 1867.]

Part II.

States and Territories west of the Mississippi River, and British Provinces.

Minnesota.

1866. *Henry H. Eames*, 1st Ann. Rep., Saint Paul, 8vo, 23 pp.
" *Charles Whittlesey*, Rep. on Mineral Regions, Cleveland, 8vo, 54 pp.

Iowa.

1858. *J. Hall* and *J. D. Whitney*, Final Rep., vol. I, Albany, 8vo, 724 pp., 29 pl., 2 sect., map.
1859. *J. Hall* and *J. D. Whitney*, Suppl., vol. I, Albany, 8vo, 4 pp.
1860. " " " 8vo, 94 pp., 3 plates.
1860. " " Ann. Rep., Des Moines, 8vo, 75 pp.
1861.* *J. Hall*, Prelim. Notice of New Crinoidea, Albany, 8vo, 18 pp.
1867. *C. A. White*, 1st Ann. Rep., Des Moines, 8vo, 4 pp.

Iowa, Wisconsin and Illinois.

1844. *D. D. Owen*, Rep. to Treas. Dept., Washington, 8vo, 191 pp., 16 pl., 4 maps.

Wisconsin and Iowa.

1848. *D. D. Owen*, Rep. on Chippewa Land Dist., Washington, 8vo, 134 pp., 23 pl., 14 sect., maps.

Wisconsin, Iowa and Minnesota.

1852. *D. D. Owen*, Final Rep. (U.S.), Philadelphia, 4to, 638 pp., 27 pl., 16 sect., map.

Missouri.

1855. *G. C. Swallow*, 1st and 2d Ann. Rep., Jefferson City, 8vo, 207, and 238 pp., 32 pl., 5 maps.
1857.* *G. C. Swallow*, 3d Ann. Rep., —— "
1859.* " 4th " " Jefferson City, 8vo, 14 pp.
1861.* " 5th " " " " "
" " Geol. Rep. on S. W. Branch Pacific R. R., St. Louis, 8vo, 93 pp., map.

Kansas.

1866. *Benj. F. Mudge*, 1st Ann. Rep., Lawrence, 8vo, 56 pp.
" *G. C. Swallow*, Prelim. Rep, Lawrence, 8vo, 198 pp.

Arkansas.

1858. *D. D. Owen*, 1st Rep., Little Rock, 8vo, 256 pp.
1860. " 2d " Philadelphia, 8vo, 433 pp.

Louisiana.

1853. *Randolph B. Marcy*, Rep. to War Dept. on Red River of La., (Geology by E. Hitchcock and G. G. Shumard; Paleontology, by B. F. Shumard,) 8vo, 320 pp., 66 sect. and plates.

Texas.

X 1859. *B. F. Shumard*, 1st Ann. Rep., Austin, 12mo, 17 pp.

ROCKY MOUNTAIN REGION.

1809. *M. Lewis* and *W. Clark*, Expedition across American Continent in 1804–6, by order United States Government, Philadelphia, 8vo, 2 vols. (London, 4to, 1814, and 8vo, 3 vols. 1817), maps.

1810.* *Z. M. Pike*, Expedition in western Territories in 1805–7, by order U. S. Government, Philadelphia, 8vo, maps, (London, 4to, 1811).

1823.* *Stephen H. Long*, Expedition from Pittsburg to Rocky Mts., in 1819–20, (War Dept.) (Compiled by Edwin James,) Philadelphia, 8vo, 2 vols. 503, and 442 pp. Atlas, (London, 8vo, 3 vols. 1823).

1824.* *S. H. Long*, Exped. to source of St. Peters River, in 1823, (War Dept.) (Geology by Wm. H. Keating,) Philadelphia, 8vo, 2 vols., maps, (London, 8vo, 2 vols. 1825).

1835. *G. W. Featherstonhaugh*, Rep. on Elevated Country between Missouri and Red Rivers, Washington, 12mo, 97 pp.

1836. *G. W. Featherstonhaugh*, Rep. on Geol. Reconn., *via* Wisconsin, to Cotean de Prairie, Washington, 12mo, 168 pp.

1843. *I. N. Nicollet*, Rep. to illustrate Map of Hydrographical Basin of Mississippi River, Washington, 8vo, 170 pp.

1845. *John C. Fremont*, Exped. to Rocky Mts. in 1852–4, (War Dept.), (Paleontology by James Hall), Washington, 8vo, 693 pp.

1848. *W. H. Emory*, Exped. from Fort Leavenworth to California, (War Dept.), includes Reports of J. W. Albert, P. S. Cooke, and A. R. Johnson, (Paleontology by J. W. Bailey), Washington, 8vo, 614 pp., maps.

" *A. Wislizenus*, Rep. of tour to North Mexico in 1846–7, with Col. Doniphan's Expd., Washington, 8vo, 141 pp., maps.

1852. *Howard Stansbury*, Exped. to Great Salt Lake, (War Dept.), (Geology and Paleontology by James Hall,) Washington and Philadelphia, 8vo, 487 pp., maps.

1853. *L. Sitgreaves*, Exped. down Zuni and Colorado Rivers, (War Dept.), Washington, 8vo.

1856. *G. K. Warren*, Exped. to Rocky Mts. in 1855, (Geology by F. V. Hayden), Washington, 8vo.

1857. *W. H. Emory*, Rep. on U. S. and Mexican Boundary Survey, vol. I, (Geology by C. C. Parry, A. Schott, W. H. Emory, and James Hall; Paleontology by James Hall and T. A. Conrad), Washington, 4to, 21 plates.

1859. *W. H. Emory*, Rep. on U. S. and Mex. Boundary, vol. II, Botany and Zoology; no Geology, Washington, 4to, plates.

1855. *Rep. on Pacific Railroad Exploration*, (War Dept.), vol. I, (Geology by George Gibbs), Washington, 4to.

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1856. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. III, (Geology, by W. P. Blake, and Jules Marcou; Paleontology by James Hall,) Washington, 4to, plates.

" *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. IV, Botany; no Geology, Washington, 4to, plates.

" *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. V, (Geology by W. P. Blake; Paleontology by L. Agassiz, T. A. Conrad, J. W. Bailey, and Geo. C. Schäffer,) Washington, 4to, plates.

1857. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. VI, (Geology by J. S. Newberry; Paleontology by T. A. Conrad), Washington, 4to, plates.

1857. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. VII, (Geology by Thos. Antisell; Paleontology by T. A. Conrad), Washington, 4to, plates.

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1859. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. X, Zoology; no Geology, Washington, 4to, plates.

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1860. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. XII, Parts I and II, Botany and Zoology; no Geology, Washington, 4to, plates.

1862. *F. V. Hayden*, Rep. on Geology of Upper Missouri Region, Philadelphia, 4to, 218 pp., map.

1865. *F. B. Meek* and *F. V. Hayden*, Rep. on Paleontology of the Upper Missouri, Part I, (Smithsonian Cont.) Washington, 4to, 135 pp., 5 plates.

PACIFIC COAST REGION.

Oregon and Northern California.

1848. *J. C. Fremont*, Rep. upon Upper California, Washington, 8vo.

1850. *James D. Dana*, Rep. on Geology of U. S. Explor. Exped., in 1838–42, New York, 4to. Atlas.

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California.

1853. *John B. Trask*, 1st Ann. Rep. Geol. Sierra Nevada, ——?, 8vo, 31 pp.

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1862. *J. D. Whitney*, Letter to Governor (Rep. of Progress), San Francisco, 8vo, 7 pp.
1862.* *J. D. Whitney*, Address to Legislat., on Survey, San Francisco, 12mo, 33 pp.
1863. *J. D. Whitney*, 2nd Ann. Rep., San Francisco, 8vo, 12 pp.
1864. *J. D. Whitney*, Rep. Paleontology, vol. I, Philadelphia, 8vo, 243 pp., 32 pl. (Carboniferous and Jurassic Fossils by F. B. Meek; Triassic and Cretaceous, by W. M. Gabb.)
1865. *J. D. Whitney*, Rep. Geology, vol. I, Philadelphia, 8vo, 498 pp., 10 plates.
1866. *J. D. Whitney*, Rep. Paleontology, vol. II, part I, Philadelphia, 8vo, 38 pp. (Tertiary Invertebrate Fossils by W. M. Gabb.)
1866. *J. D. Whitney*, Letter to Governor on Survey, San Francisco, 8vo, 14 pp.

California and Arizona.

1861. *Joseph C. Ives*, Rep. on Colorado River, Washington, 4to, plates, (Geology and Paleontology by J. S. Newberry.)

BRITISH PROVINCES.

Newfoundland.

1839.* *J. B. Jukes*, Prelim. Rep. (Legislative Doc.), folio, St. Johns.
1842.* " General Rep. in Author's "Excursions in and about Newfoundland," London, 12mo, 2 vols. (Separate, with sections, London, 12mo, 160 pp. 1843.)

Nova Scotia.

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1862. *Henry Poole*, Rep. on Gold-fields, Western Section. (Appendix on Minerals, by H. How.) (Legis. Doc.) Halifax, folio, 25 pp.
1862. *J. Campbell*, Rep. on Gold-fields, Eastern Section. (Legis. Doc.) Halifax, folio, 8 pp.
1863. *J. Campbell*, Rep. on Gold-fields. (Legis. Doc.) Halifax, folio, 12 pp.
1864* *David Honeyman*, Rep. on Geol. Survey of Nova Scotia, and Cape Breton. (Appendix on Minerals by H. How.) (Legis. Doc.) Halifax, folio, 7 pp.
1865. *H. How*, Rep. on Minerals collected by D. Honeyman. (Legis. Doc.) Halifax, folio, 4 pp.

New Brunswick.

1839. *Abraham Gesner*, 1st Ann. Rep., St. John, 8vo, 87 pp.
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“ *Henry Y. Hind*, Rep., especially on the Quebec Group, Frederickton, 8vo, 293 pp.

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1863. “ General Report, from 1843 to 1863, Montreal, 8vc, xxvii and 983 pp. Atlas.
1858. *E. Billings*, *J. W. Salter* and *T. R. Jones*, Decade III, Cystideæ, Asterideæ and Entomostraca, Montreal, 8vo, 102 pp., 11 pl.
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1865. *E. Billings*, Paleozoic fossils of Canada, Montreal, 8vo, 426 pp.
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1866. *W. E. Logan*, Rep. Progress from 1863 to 1866, Ottawa, 8vo, 322 pp.

British America.

1858. *Henry Y. Hind*, Rep. of Explor. between Lake Superior, and Red River, Toronto, 8vo, 425 pp., maps.
1860.* *H. Y. Hind*, Rep. on Assiniboine Exped. in 1858–9, Toronto, folio, maps.

1863.* *H. Y. Hind*, Rep. of Explor. in Labrador, London, 8vo, 2 vols., maps.

1860. *Oscar M. Lieber*, Rep. on Geology of Labrador, (U. S. Coast Survey), Washington, 4to, 7 pp.

ARCTIC REGIONS.

1819. *John Ross*, Voyage to Baffins' Bay, &c. (Appendix, on Geology, by John McCulloch), London, 8vo.

1822. *John Franklin*, Exped. to Polar Sea, 1819–22. (Appendix on Geology by John Richardson), London, 4to.

1828.* *W. E. Parry*, 3d Voyage of Discovery in 1827. (Appendix on Geology by Robt. Jameson), London.

1828. *J. Franklin*, 2d Expd. to Polar Sea in 1825–7. (Appendix on Geology, by J. Richardson; Paleontology, by R. Jameson), London, 4to.

1835. *J. Ross*, 2nd Voyage of Discovery in 1829–33. (Geology by Author,) London, 4to, 2 vols.

1836.* *G. Bach*, Arctic Land Exped. in 1833–5. (Appendix on Geology, by W. H. Fitton), London, 8vo.

1839. *F. W. Beechey*, Exped. to Pacific and Behren Strait. (Appendix on Geology, by Wm. Buckland), London, 4to.

1852.* *P. C. Sutherland*, Journal of Voyage in Baffin's Bay, in 1850–51. (Appendix on Geology, by J. W. Salter), London, 8vo, 2 vols., plates.

1855. *E. Belcher*, Exped. to Arctic in 1852–4. (Appendix on Geology, by J. W. Salter), London, 8vo, 2 vols.

ADDITIONS TO PART I.

FLORIDA.

1851. *Louis Agassiz*, Rep. on Florida Coral-reefs, (U. S. Coast Survey), Washington, 8vo, 15 pp.

1864. *E. B. Hunt*, Rep. on Florida Coral-reefs, (U. S. Coast Survey), Washington, 4to, 7 pp.